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A NESTING CRANE IN THE ZOOLOGICAL PARK. THIS SPECIMEN IS SO SAVAGE THAT A KEEPER MUST CONTINUALLY BE ON GUARD AGAINST ITS POWERFUL BEAK.

THE CRANE COLLECTION OF THE NEW YORK ZOOLOGICAL PARK.—[See Page 200.]

Handling Passengers on a Rapid Transit Railroad—II*

Construction of a Rapid Transit Line as Illustrated by the Hudson and Manhattan Railroad

By J. Vipond Davies

Concluded from Supplement No. 1838, page 179

It is not possible in all cases to load passengers so that they will be evenly distributed throughout the train, as is the case at Church Street terminal. For instance, at Hoboken terminal the only connection available for interchange of passengers with the Lackawanna Railroad enter the first car they come to and fill the cars at one end of a train, leaving the cars at the other end practically empty. To counteract this unequal train loading an entrance for passengers interchanged with the Public Serice Corporation (trolley cars) was constructed as near as possible to the other end of the station, and the result is a well-balanced arrangement for the distribution of passengers throughout the entire train. Similarly, at the Pennsylvania station passengers from the railroad are necessarily delivered to the Hudson and Manhattan Railroad at the extreme easterly end of the station, and to counterbalance this, entrances for passengers from the trolley cars and street are located at the westerly end of the station. The local stations on Sixth Avenue have all been arranged with entrances and exits as near as possible to the center of the train, whereas the stations at Christopher Street and Ninth Street, owing to curves in the line which prevented the platform from being centered on the only available site for a stairway and entrance, are arranged for end loading—Christopher Street at the westerly end and Ninth Street at the easterly.

In the design and construction of the stations of the New York rapid transit subway practically all the entrances and exits consist of openings in the sidewalks covered by kiosks, which interfere seriously with the use of the sidewalk. In the development of the Hudson and Manhattan lines the Rapid Transit Commission appreciated the objections to the kiosks erected on the sidewalks and compelled the company to arrange for the entrances and exits through private property unless specifically permitted to do otherwise by the Commission. In some cases arrangements were made for entrance and exit through private property on Sixth Avenue, and in other cases entrances and exits were placed under the stairways leading to the elevated railway, so that the erection of kiosks involved no additional obstruction on the sidewalk. To make a railroad of the greatest convenience to the traveling public, the stations need be clearly defined and easy of access. An entrance through private property seldom affords the same convenience to the public as does an entrance direct from the public streets, even at the expense of obstructions such as railings or kiosks. Entrances placed directly upon the street are more in evidence, and are consequently of greater value to the public, so that although, at first thought, the obstruction to the sidewalk may be considered as pre-eminent, yet the general convenience of the traveling public is better served by kiosks. On the other hand, where it is possible to arrange stairways, as was done on the Hudson and Manhattan Railroad, under the stairs of the eleated railway, so as to provide this convenience without additional obstruction to the sidewalks, the arrangement is ideal. There is, however, one serious drawback, as in the majority of cases the stairways to the elevated railway are so narrow as to give inadequate width for proper service, and wherever there is a possibility of passengers moving in opposite directions no stairway should be installed less than five feet in width, and it is desirable to make them not less than six feet wide, which allows ample width for two persons abreast walking in the direction of the maximum movement and one person in the direction of contrary movement. The interference with the movement of passengers in the maximum direction by an opposite movement on narrow staircases is detrimental to general efficiency.

Platforms should be designed to provide ample room for the free movement of passengers. In the case of unloading platforms all that is necessary is to have sufficient space with ample exits, so that an entire trainload of people can be easily discharged onto the platform within the limit of time fixed for the station stop, and, further, that the entire trainload so discharged may pass out of the station before the arrival of the following train. It is usually not necessary for a platform to be wider than the floor area of the car itself, although there should be a widening of platforms in the vicinity of stairways or exits, as there must of necessity occur a slight congestion at the points of exit from the unloading platform. In the case of loading platforms, the consideration is affected materially by the character of train service operated. With the Hudson and Manhattan Railroad at Church Street terminal, and later at the Thirty-third Street terminal, there are in use platforms twenty feet wide, common to trains serving different routes. There must, therefore, be ample room on the platforms for an entire trainload of people to stand for either route for which a train is destined and to distribute themselves so that they can enter the train immediately upon its arrival. It is obvious that if an attempt is made to unload passengers from an arriving train onto the same platform on which passengers waiting to leave on the same train are standing, the movement of passengers is seriously interfered with and the public inconvenienced, since the station stop must be increased to permit loading and unloading of the trains. It is very plain, therefore, without argument or the use of figures, that the convenience of the public and the rapidity of passenger movement can be best accomplished by unloading passengers onto one platform and loading them from another. It is quite material in unloading passengers that the train stands on a tangent. The great objection to a train standing on a curve at a station is that passengers may be injured by stepping through the gap between the train platform and the station platform. In the Rapid Transit Subway in New York, as well as elsewhere, this gap has been illuminated by lights underneath the edge of the platform which clearly indicate the gap, and assist materially in avoiding accidents, but, apart from the possibility of accidents, the location of a station platform on a curve, with the consequent gap between the platform of the car and the station platform, seriously affects the rapidity of movement of passengers either entering or leaving the train. There is an instinctive pause by each individual seeing the gap; the movement is much slower in consequence, and the length of the station stop is materially lengthened.

The arrangement of ticket offices is important in station design. At first sight this seems like a matter requiring little attention, but as a matter of fact it is essential in the economical operation of a rapid transit railroad and in the efficient handling of passengers. In arranging ticket offices it is vitally important to locate them so as to force passengers as far as possible to move in the right-hand direction, and it is also important to arrange the position and grouping of the ticket offices so that the line of passengers purchasing tickets will not be interfered with or crossed by passengers leaving the station or by those with tickets desirous of reaching the trains. Ticket offices for the sale of steam railroad tickets should be located in convenient sight of travelers, but entirely out of the stream of traffic, whereas for the sale of strip tickets, used in rapid transit service, the boxes must be located along the direct stream of movement, so that no passenger leaves his general direction, and yet so grouped that while one stream of persons is purchasing tickets, there is unobstructed opportunity for those persons already having tickets to pass along. The arrangement of ticket windows in tandem on the same face is valueless, for the reason that those who are buying tickets at the first window must of necessity cross the stream of passengers trying to obtain tickets at the second window, which invariably causes discomfort and obstruction. The Hudson and Manhattan Railroad has carried out the usual arrangement of installing one large and important ticket office at a station in which the ticket agent can keep his safe, stock of tickets, and cash, and in addition has provided sundry portable ticket offices which can be wheeled into line during the busy hours and moved entirely out of the way during the slack hours. In all cases the arrangement of ticket offices should be such that the ticket-chopper is near to the ticket-seller, so that the seller may have the chopper under observation, and so that in case of necessity the ticket-chopper may assist the ticket-seller. However, the distance between the two should be such as to permit a passenger, after having purchased a ticket, to pause before putting the ticket into the chopping-box. One ticket-chopper usually serves two lines or streams of traffic, and the barriers should be only so wide as to allow a single file of passengers to pass on each side of the chopping-box. The most convenient and desirable width for this passage is 24 inches. With the ordinary stream of passengers on this road it is found that one ticket-chopper can pass through the gate in two files 108 passengers per minute. This rate of passage is too great, however, except for short spurts, as the chopper cannot properly examine tickets, and provision should be made for an average rate per chopper not exceeding 4,000 persons per hour. An examiner who has to punch or personally scrutinize railroad tickets can only pass about 30 per minute. An ordinarily competent ticket agent will sell about 2,000 rapid transit tickets per hour and make change, or for short periods may sell as many as 2,500 tickets per hour. In calculating the number of selling agents or chopping-boxes necessary for handling the maximum traffic, these figures can be taken as a basis for speed.

In connection with the stations there is one other matter to which reference should be made: that is, the necessity for the use of elevators or escalators at certain points in the underground railroad where the depth of the station below the surface is considerable. The new plans of the Public Service Commission require them when the lift exceeds 30 feet. This is provided on the Hudson and Manhattan Railroad at the Pennsylvania station in Jersey City. The capacity of an escalator is usually thought to be considerably greater than the capacity of an elevator, on account of an escalator taking a continuous stream of people and moving them as they arrive without an intermission or pause, which is of considerable importance; as a pause, however short in duration, affects materially the flow of passenger movement. The elevator service was installed at the Pennsylania station, therefore, on account of the absolute necessities of the case, as it was impossible by any arrangement which could be devised to lay out an escalator service at that point, and the conditions were ideal for the installation of an elevator service. The company provided elevator service with the utmost appreciation of the possible congestion arising therefrom. The size of the elevators was limited by the width of panel in the main bracing of the elevated station and allowed cages only 10 feet square. Further, the Pennsylvania Railroad Company could not, without seriously affecting its own business, spare the concourse floor room sufficient for more than four elevators. The capacity of these elevators, on the basis of allowing two square feet per person, is fifty persons per lift, and as the lift of about 92 feet is continuous from bottom to top, and *vice versa*, it was agreed to operate at the comparatively slow speed of 300 feet per minute, particularly as the actual running time of the elevators is small when compared with the total elevator interval. To facilitate the movement of passengers the scheme of dividing incoming and outgoing passengers, was used; the same as in the other stations. This was done by providing openings on the front and rear of the elevator cages, receiving passengers from the Pennsylvania Railroad trains direct into the elevators from the train side and discharging passengers from the tunnels to the Pennsylvania Railroad trains on the opposite side. The gates are as nearly the full width of the elevators themselves as they could be made. It was possible to get an effective gate opening of 6 feet 3½ inches in width, and to equip the elevators with a pneumatic device by which the elevator operator controls the opening and closing of the doors of the cages and elevator fronts. The result of the layout has thus far greatly exceeded the original idea of its possibilities, and has more than satisfied the officers of the Pennsylvania Railroad as to capacity. It is usually not desirable to attempt to fill the cages to their maximum capacity, and to handle passengers most efficiently and expeditiously it is found that a load of forty persons will accomplish more than one of fifty, on account of the delay in loading the additional ten people. In this manner, the four elevators can handle passengers at the rate of sixty people per minute in one direction. On one occasion five fully loaded suburban trains of the Pennsylvania Railroad, after being stalled at Point of Rocks outside Jersey City, came into the station practically in a procession, and the passengers moved into the elevators as they arrived without the slightest congestion or undue inconvenience. An elevator of the size installed at this station is probably more efficient for the rapid handling of passengers than one of large floor space, as the service is so rapid that there is practically no pause in the flow of people.

Cars.—In handling passengers, the second important point is the design of car, particularly with reference to loading and unloading, and its internal arrangement as affecting the passenger, and its relation to the

* Proceedings of the Engineers' Club of Philadelphia.

station. In the first place, the train service operated by the Hudson and Manhattan Railroad is essentially a short-distance service. The longest continuous distance usually traveled by a passenger—from Pennsylvania station to Thirty-third Street, or from Hoboken terminal to Church Street terminal—is less than four miles, consequently the time a passenger is in a car is comparatively short, and not comparable with the time taken on a railroad such as the electrified lines of the Long Island Railroad, or the Interborough Rapid Transit Subway, where a passenger may ride from 20 to 25 miles on a continuous trip. It is a well-known fact that a crowd of people desirous of traveling on a train will insist on using the first train in every case, and will jam itself into a train whether there is sitting room or not, notwithstanding that another train is following within ninety seconds, and in spite of the fact that crowding an already overloaded train materially lengthens the time of the station stops and interferes with the headway and progress of all following trains. The next following train may be running practically empty. It is, therefore, not essential on a road such as the Hudson and Manhattan, to attempt to provide the maximum seating capacity in a car, but it is necessary to give the maximum seating capacity only under ordinary conditions and at ordinary hours, and to give the greatest floor space, for standing room, and for carrying the maximum number of people in the easiest way with the least obstruction and inconvenience due to deliberate overcrowding.

The Hudson and Manhattan Railroad trains are essentially moving terminals for the steam railroads; a very large number of passengers carry valises and other baggage; consequently, the car with the greatest unobstructed floor area is the most advantageous for such service. For this reason it is desirable to arrange the seats along the sides of the car without cross-seats, which possibly would have given but four or six seats additional per car, but which would have obstructed very materially the rapid movement of passengers. This arrangement gives a seating capacity of forty-four persons per car. A novel feature of this scheme for seating is the subdivision of seats into sections, which was devised by Mr. Stillwell. This scheme was adopted because most of the passengers desire corner seats, and for the purpose of stiffening the side trusses of the car. The subdivision of seats into sections is convenient and has proved to be very popular.

The use of the enameled rods in place of straps adds another convenience for passengers. Enameled rods are more sanitary than leather straps, and a new enameled metal loop is being tried by the Rapid Transit Subway as a substitute for leather straps.

The newspapers have so thoroughly educated the public as to the merits and demerits of side doors for cars that there is little to add here. Side doors were first used in a practical way on the Hudson and Manhattan road, and with complete success; but to get the maximum efficiency they should be used in conjunction with platforms at the level of the car floor and with station platforms arranged for loading passengers on one side and unloading on the opposite side. The cars have a clear opening of 36 inches for each end door and 41 inches for the side door. With these conditions 106 people can be unloaded in twenty-nine seconds, or at the rate of 3.65 per second, and there is not the necessity for the very wide doors which are essential where the loading and unloading is from the same side. The earlier cars of the Rapid Transit Subway were arranged with only end doors having an effective opening of about 33 inches. This is wider than is strictly necessary for a single line of passengers, but at the same time altogether too narrow for a double line. Cars more recently built and provided with side doors have an effective opening of 47 inches, which permits a double line of persons outward, or a single line of passengers moving out and a single line moving in at the same time; but even with these wide openings, the result is not as expeditious as with loading and unloading on opposite sides.

The installation and operation of side doors is complicated in opening and closing, as the side doors are necessarily out of sight of the guards standing at the end of the car, and the doors cannot conveniently be opened and closed by men on the platform. It would be a very serious burden to maintain men on every platform to operate the side doors. On the Hudson and Manhattan Railroad all car doors are equipped with a pneumatic device for opening and closing, and there are air-cushions on the edges of the doors. No trouble whatsoever in the operation of the doors, and practically no accidents of a serious nature, have occurred. The Rapid Transit Subway has equipped the side doors of its newer cars with mechanical devices operating with a chain and toothed gears, which appear to operate satisfactorily.

Generally speaking, in rapid transit service the conditions are different from street railroad conditions by reason of the fact that on a street railroad passengers get on and off the cars and trains anywhere, and that fares are collected in each car at the point where a passenger gets on, which makes the entire distance the car travels practically a continuous station. In any rapid transit or high-speed line it is necessary to make definite stops at stations and to equip each station properly for the sale and collection of tickets instead of on the trains.

The greatest complication, in connection with a moving platform device, is in making it a continuous station. One of the points of advantage in a moving platform is the fact that the whole distance can be made a station, practically the condition on a street railway; but it is almost impossible to equip the whole length of the platform with ticket agents.

The capacity of trains is regulated, as before outlined, by the capacity of the cars forming the trains. The frequency is regulated by the time interval at which trains can be operated, and is irrespective of the speed of trains, which affects only the convenience of the public, and the ability of a railroad to get business. A railroad is a commercial enterprise, and while it is constructed for public service, it is primarily constructed with a view of obtaining an adequate return on the money invested. To obtain this result, therefore, on a private or public investment, it is essential to operate with the greatest efficiency, and to so design a railroad that it can give maximum service.

Therefore the details presented here will indicate the importance of not sparing trouble or expense in designing, constructing, and equipping a railroad so as to give the greatest service with the least inconvenience to the traveling public combined with maximum efficiency and economical operation. The essential point with a public service corporation is to serve the public properly, and this was the underlying thought of Mr. McAdoo, the president, when at the opening of the Hudson and Manhattan Railroad he addressed the employees with words to the effect that he wanted no effort spared in the operation of the railroad to please the public.

If it is conceded that a rapid transit railroad is a public utility, then there is also implied a mutual obligation between those who operate the road and the public authorities who grant franchises and regulate the service, to treat each other in a broad-minded manner, and to co-operate in providing rapid transit facilities which will be of the greatest service and convenience to the traveling public.

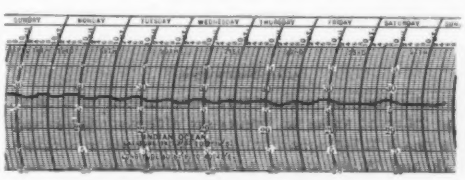
An Instructive Barogram

We are indebted to the Taylor Instrument Companies for permission to reproduce the accompanying barogram, which was obtained by Mr. P. R. Jameson, F.R.Met.S., in the course of a voyage around the world. The particular week's record here shown was made on shipboard between Mozambique and the coast of British East Africa; i. e., the vessel was going nearly due north, and passed through about 12 degrees of latitude during the week.

While this record offers nothing of special note from a meteorologist's point of view, it is, in fact, a perfectly normal record for the region and season in question, making allowance for the fact that the barograph had probably not been adjusted for some time and read much too low. It is presented to our non-meteorological readers as a pretty illustration of the very regular diurnal fluctuations of the barometer within the tropics, with the additional effect due to a rapid translocation of the instrument in latitude. The ship was sailing from a region in which the barometric pressure is permanently high—viz., the ridge of high pressure in the neighborhood of the Tropic of Capricorn—toward one in which it is permanently low, viz., the "doldrums"—the belt of calms near the equator, between the two trade-wind belts. This accounts for the progressive fall of pressure from the beginning to the end of the record. The effect is, however, somewhat greater than would be expected from the normal distribution of pressure in this region, and was possibly heightened by an accidental tilting of the trace-sheet with respect to the revolving cylinder of the barograph.

If the reader will compare this barogram with one made in temperate latitudes he will be struck by the clock-like regularity with which a maximum of pressure occurs at 10 A. M. and a minimum at 4 P. M., with secondary maxima and minima at 10 P. M. and 4 A. M., respectively. There is an oft-quoted saying of Humboldt's to the effect that so regular is the daily rise and fall of the barometer within the tropics that the time of day may be inferred from it with considerable accuracy. The daily range averages about one-tenth of an inch of the mercurial column. Day after day the history of the barometer repeats itself. The monotony of the process is varied only—and at any given place this occurrence is fortunately rare—when a tropical hurricane passes near the point of observation. Hence in tropical countries any departure of the instrument from its accustomed daily course is looked upon as ominous.

In temperate regions the barometer has a similar double diurnal period, but the periodic range is less, and near the poles it is almost *nil*. Moreover, outside the tropics this daily oscillation is, as a rule, completely



AN INSTRUCTIVE BAROGRAM

masked by the passage of those widespread areas of hyperpressure and hypopressure that we call, respectively, "highs" and "lows." Within the tropics these disturbances are almost unknown, except for the small but intense "lows" known as tropical cyclones or hurricanes. Furthermore, the latter are, in any given region, limited to a particular season of the year, and they rarely, if ever, occur over the southern Indian Ocean during September, the month in which the accompanying record was made.

The cause of the double daily oscillation of the barometer is one of the time-honored riddles of meteorology. No one has yet completely unraveled it, though of late much light has been thrown upon the subject. The daily march of temperature—with a minimum in the morning and a maximum in the afternoon—would lead us to expect a *single* daily oscillation of atmospheric pressure. When the air near the earth's surface is heated it expands, pushes its way upward, and overflows, thus diminishing the total mass of the air over the heated region and causing the barometer to fall. The converse occurs when the air is cooled, and then the barometer rises. This process alone would give us a daily maximum and a daily minimum of pressure twelve hours apart, instead of two maxima and two minima, at intervals of six hours, such as actually occur.

The explanations of this double period hitherto offered are too intricate to explain here in detail. An analysis of pressure records obtained in all parts of the world has shown that the curve representing the daily march of the barometer at any place is really a composite of two curves. One of these has a daily period, and is evidently a local temperature effect; the other, which is the more regular of the two, appears to depend upon the normal vibration period of the whole atmosphere; a resonance effect, as it is technically called. The reader who desires to pursue this subject further may do so in Hann's "Lehrbuch der Meteorologie" (2d ed., Leipzig, 1906).

Fruit Disease Investigations

The investigation and study of fruit diseases have been vigorously pushed and have shown a healthy progress. The destructive tumor disease of limes and other citrus fruits has been shown to be of fungus origin and attacks oranges as well as limes. The new methods of spraying with sulphur compound worked out by the pathologists of the Department has been widely adopted by apple growers. The investigation shows that fine fruit can be produced and protection secured against fungus disease without the injurious effect resulting from copper compound. Bordeaux mixture is still being used, but in the spraying of apples it has taken second place. Special attention has been given to experimental work in perfecting the method of using the new sulphur sprays for the fruit spot and leaf disease. As a result, fruit growers who have used the new sprays have secured fine crops of the best apples they have ever grown. Spraying has very largely prevented the fruit spot and leaf disease known as cedar rust, or orange rust, prevalent in the Blue Ridge and Allegheny mountain district from Pennsylvania to Tennessee. The peach growers of Virginia, West Virginia, and Georgia have been prompt to adopt the discovery of spraying with self-boiled lime-sulphur for brown rot and scab, which has resulted in the removal of some of the factors which rendered the growing of this fruit uncertain. The pear blight eradication methods have been in extensive use on the Pacific coast.

Much space is given in discussing the work of the Bureau of Entomology to the important work that bureau has done during the past year in its effort to control or eradicate the gipsy moth and the brown-tail moth. The infested territory covers all the New England states excepting Vermont, and the Department, working in co-operation with the authorities of those states, has met with gratifying success. Conditions there are largely improved.

Mechanical Aids to the Study of Marksmanship

A German Army Officer's Invention

LIEUTENANT VON STEGER of the German army has invented a simple apparatus which facilitates instruction in marksmanship and shows the recruit the character and extent of the error made in aiming. This apparatus, which is described and illustrated in *Kriegstechnische Zeitschrift*, is made in two parts. The first part (Fig. 1) is a pair of sights, of the point and notch type used on rifles, constructed on an enlarged scale and so mounted on a tripod that it can be turned in any direction. The height of the point and the breadth of the notch are each about two inches, and the point and notch are mounted on the ends of a strip of wood about three feet long, which is attached to the tripod by a double joint, moving with slight friction. The second part (Fig. 2) is an adjustable sight hole, consisting of a wooden disk with a perforation one-fifth of an inch in diameter, which is attached to a tripod by a jointed arm moving with slight friction.

It has been the practice of instructors in marksmanship to employ enlarged wooden sights, laid one upon the other, for the purpose of showing the correct and incorrect positions of the point with respect to the notch, but many unintelligent recruits cannot understand the demonstration because the sights on the rifle are not in contact, but are widely separated. Much better results can be obtained with the new apparatus. The recruit stands a pace or two behind the sight hole and looks through it at the pair of sights, one pace farther forward. No target is required. By means of the adjustable sight hole the eye can be fixed in any position and the correct relative positions of the point and notch, as well as any deviation therefrom, can be easily demonstrated.

In the exercise in which the pupil is required to designate the point at which a rifle has been aimed by the instructor, the pair of sights is placed ten paces from a disk of cardboard or canvas, with the point nearest the target. The instructor aims the sights and the recruit, standing about one pace from the notch, indicates the point on the target at which he thinks the sights are aimed. This point of the target is marked with a black patch. The instructor then places the sight hole before the pair of sights so that an eye looking through the hole sees the notch bisected by the point. If the recruit has judged correctly the black patch will be seen directly above the point, but if he has judged incorrectly the patch will be seen to the right or left of the point (Fig. 4). The recruit, looking through the sight hole, can thus see his error. Or the sight hole may be so placed that the patch appears exactly over the point. In this case the error is shown by the unsymmetrical position of the point in the notch (Fig. 5).

FIG. 1.—MOVABLE PAIR OF SIGHTS

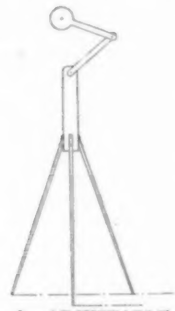


FIG. 2.—ADJUSTABLE SIGHT HOLE

FIG. 4

FIG. 5

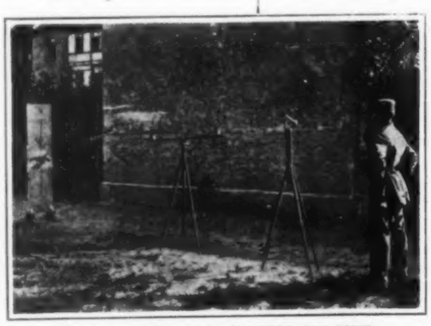


FIG. 3.—THE APPARATUS IN USE

The apparatus is used in a similar way in the exercise in which the pupil is required to aim at a mark chosen by the instructor, and the error is shown, as before, by using the sight hole, which is adjusted by the instructor. The apparatus is not intended for universal use, but only as an aid in the instruction of the less intelligent and especially awkward recruits, where it saves much time and vexation and teaches accuracy of aim. The pupil sees his own error because his eye is brought to the correct position by the sight hole. Without the apparatus the instructor can only say that the gun is aimed too high, too far to the right, etc., but the recruit has to take this verdict on faith and is little helped by it. The movable pair of sights might be dispensed with and the sight hole attached to the butt of the rifle, but this arrangement would be less convenient and less accurate, owing to the nearness of the hole to the notch.

A Handsome County Bridge

A Reinforced Concrete Bridge Connecting Asheville with West Asheville

THE handsome reinforced concrete bridge represented in the illustration spans the French Broad River, connecting the city of Asheville with West Asheville, a thriving and energetic little city of 3,500 people. The entire construction is of reinforced concrete, with a total length of 931 feet 6 inches. It is composed of two clear spans of 145 feet each, with an east approach of 475 feet, and a west approach of 135 feet. The distance from the top of the bridge at the center of the arc to the water at normal level is 50 feet. The structure has a 30-foot roadway with an electric car line in the center, and a 12-foot 6-inch clear roadway on each side of the rail. It was designed for a capacity of three 35-ton electric cars. The total cost of the bridge was $70,000, and including right of way and incidentals, $72,000. R. P. Johnston, of Asheville, N. C., was the engineer, and C. B. Clarke & Company, Baltimore, were the contractors. The bridge was opened to the public on February 10th, 1911.

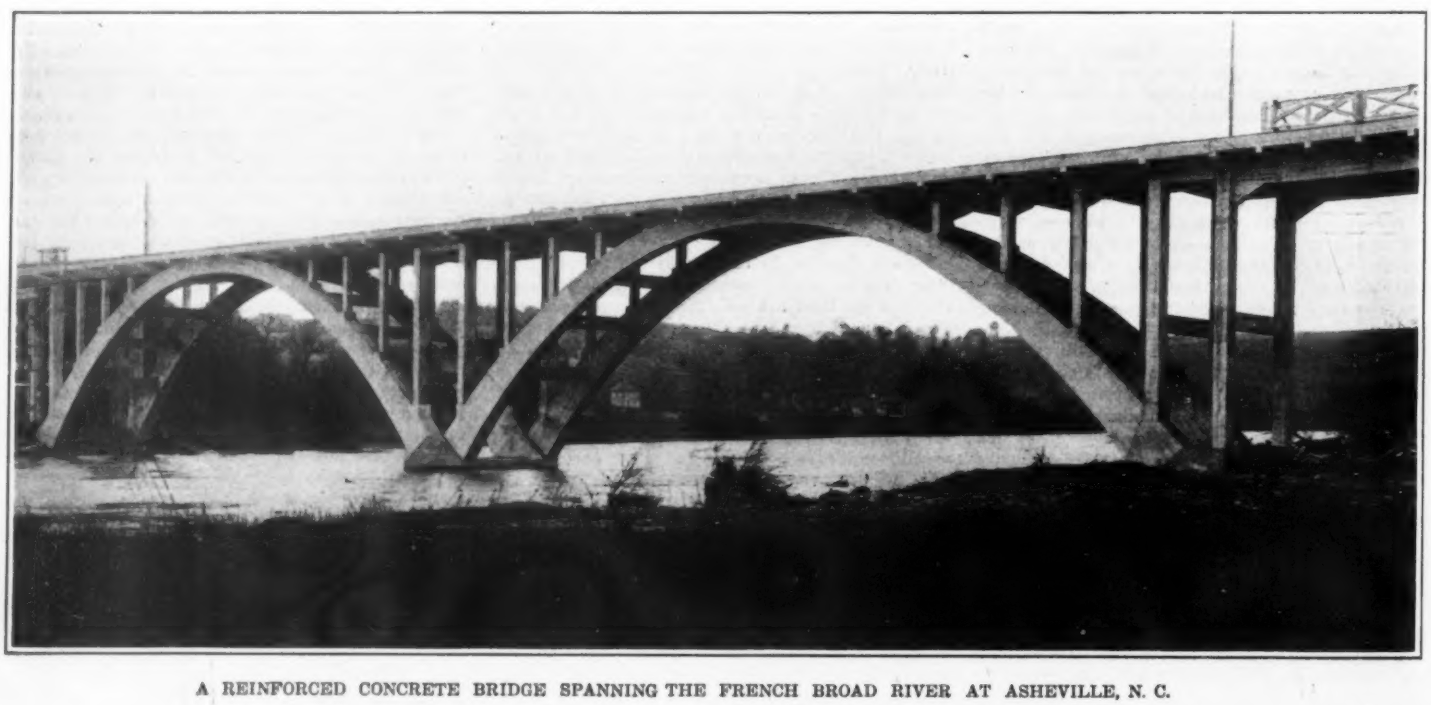
The Asheville Electric Company is extending its line across the bridge, to the western portion of West Asheville, a distance of a little more than two miles, at a cost of nearly $40,000. Large forces are at work at both ends of the line and cars are expected to be in operation by April 1st, 1911.

Soil Surveys

DURING the year soil surveys were carried on in fifty-nine different areas in twenty-six different states, and as a result 22,762 square miles were covered in detailed work and 79,108 square miles of reconnoissance surveys, mainly in the Great Plains region. A total area of 359,564 square miles, or 230,120,960 acres, has been surveyed and mapped since active field work was begun in 1899.

It is now clear that the pioneer methods of agriculture are inadequate for the increasing needs of our growing population. There is also abundant evidence that with a thorough knowledge of the soils and the intelligent application of modern intensive methods the yields per acre of our staple crops can be increased many times.

The soil surveys are showing the vast opportunities for crop specialization in the various soils in different sections of the country. Reconnoissance surveys of the Great Plains region thus far made have furnished a large amount of valuable and accurate information, not only to prospective settlers, but also to those farmers who are already in the areas.



A REINFORCED CONCRETE BRIDGE SPANNING THE FRENCH BROAD RIVER AT ASHEVILLE, N. C.

Curved Photographic Plates*

Their Advantages in Astronomical Photography

By F. A. Bellamy, Hon. M.A. (Oxon.), F.R.A.S.

A short note on the subject of curved photographic plates may be of interest. From the earliest days in photographic astronomy one of the difficulties to be met and overcome was the curvature of the field, or the rapid falling off in the definition or good focus in the images of the stars away from the center of the photographic plate. It is obviously of the greatest importance, for accuracy and utility, for uniformly good quality definition to be obtained over as large an area on the plates as possible.

To an astronomer the reduction of the aperture of the photographic lens is not permissible, or, at least, usually very inadvisable for stellar work, as the maximum aperture is required in order to reduce the time of exposure as much as possible.

Though curved plates have in the past been suggested and used with a view to overcome the want of good focus beyond a very limited area, they have never found favor with astronomers, for various reasons, among these being the difficulty of making them uniformly suit the area of good focus simultaneously at the center and the edges, the great cost of making satisfactory plates (uniformly coating them), greater risk of breakage, difficulty of measurement, storage, and so on. When the first conference in connection with the Astrographic Survey was held in Paris, in 1887, one of the subjects proposed and discussed was the use of curved plates for the survey: The plan was rejected as not feasible. In twenty-three years knowledge has advanced, and the utilization of methods and appliances—common in other branches of science—has greatly increased; so that what was impossible or inconvenient years ago is now rendered more convenient and available for use.

The suggestion to use curved plates has been brought up again. This time, from a personal acquaintance with the worker and his excellent work, we may say that there is a much greater chance of the method being tried under every condition that promises success, which, we hope, will ultimately be achieved by Dr. J. H. Metcalf.

The lens he is using is a Petzval doublet, and the focal length is seven times the aperture and gives a scale of picture of 90 inches to 1 millimeter. With this lens he has found by re-focusing for various parts of the plate that all parts of a 10-inch by 8-inch plate, equal to an area of 5 degrees square, can be brought into good focus, and excellent star images obtained. As the lens can do so much by merely altering the

* *Knowledge.*

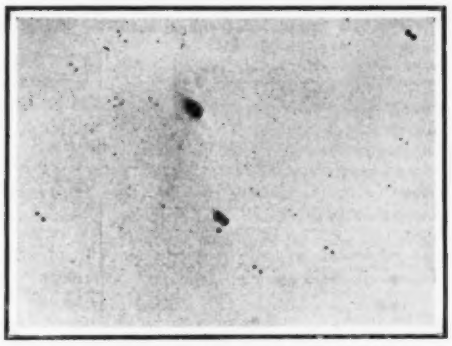


Fig. 1.—THE CENTER OF THE PLATE

Two exposures were made on the same plate, the left hand one with the plate curved, the other with it flat

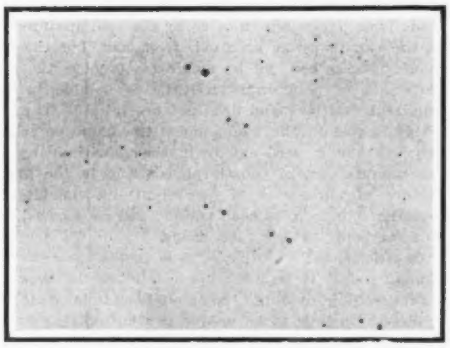


Fig. 2.—THE EDGE OF THE PLATE

Here there were two exposures as in Fig. 1

focus gradually between the center and the edges, the extreme amount to be allowed for in changing the focus for these two positions is only three one-hundredths of an inch (0.8 millimeter); it seems quite possible to bend a plate temporarily by that amount without fracture.

Various methods were tried to produce the required amount of bending artificially; of these the most successful, as one might expect, is that produced by atmospheric pressure on the outer and film side surface of the plate, caused by exhaustion of the air in a closed chamber at the back of the plate.

From a trial made with the 16-inch Metcalf telescope in 1910, June 29th, ocular evidence can be obtained by the examination of the two sets of star images shown on the accompanying illustrations. The region is that surrounding R.A. 19h. 0m. and + 5 degrees, and is enlarged nine times from the origin plate, so that 10 inches equal 1 millimeter. In obtaining these two exposures the first and left-hand image was taken with the plate temporarily curved and the second image shows the same star with the plate flat; each exposure was of ten minutes' duration. In Fig. 1 the center of the plate is substantially in the same focus, the flat plate image being slightly the better one of the two. When the outer parts of the same plate are compared a marked improvement becomes obvious with the curved plate images, the bright stars showing less diffusion, and naturally smaller images, there being less scattering of light; and the faint stars—the stars' light being more compact and in focus—are distinctly improved; almost invisible and diffused images become quite visible and better formed.

Further plates have since been taken with that instrument to test the effect on the determination of magnitude and of position. From an examination of sixty-one stars, fainter than the 10th magnitude, it was found that the flat plate lost 0.17 magnitude at 1.5 degree from the center; in the curved plate the brightness increased by 0.06 magnitude: No systematic error was detected.

The effect on the actual positions of the stars has not yet been determined; this requires careful and accurate measurement of a number of plates, preferably of the same area.

For the convenience of use, storage, and measurement, it will be a distinct gain to be able to have the plates flat rather than have to deal with plates with a permanent curvature. When the temporarily curved plates are measured there are obvious advantages in having them flat in the measuring instrument.

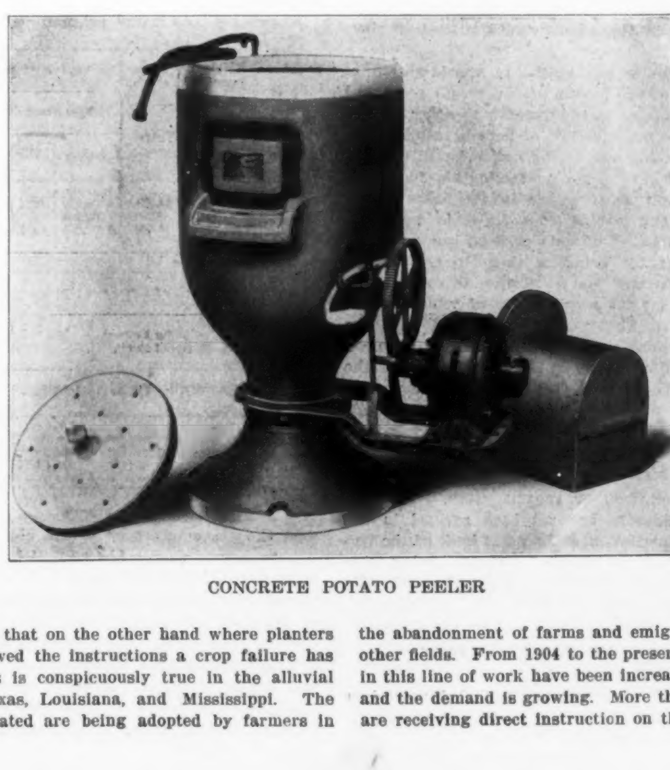
The plate reproduced here is from the Harvard Circular, No. 161.

Knowing Dr. Metcalf's skill in practical photographic astronomy, and his power to overcome difficulties, we may expect still better results from his instruments.

A Concrete Potato Peeler

A novelty in cement construction is a concrete potato peeler. It is an urn-shaped reinforced concrete vessel, which has a revolving disk in the bottom of the bowl, driven from below through bevel gearing, and designed to spin the potatoes around the inside of the bowl. The rough surfaces on the disk and bowl rub off the potato skins, and several sprays of water injected at the upper edge wash the potatoes clean and carry the refuse out at the bottom. It peels a peck of potatoes perfectly in two minutes, and while the machine is still running a door in the side is opened and the potatoes are ejected by centrifugal force into a galvanized iron receptable. A motor of one-half horse-power capacity furnishes ample power, and the driving pulley is proportioned to give six hundred revolutions per minute to the disk. It is claimed that the machine saves twenty per cent of potato which is wasted by hand peeling, to say nothing of the saving in labor and time. Deep eyes and corners in irregular potatoes must, of course, be removed with a knife.

The machine is cast upside down, using mortar of a consistency which pours readily. The mold is made of cast iron, in several sections, and includes a collapsible core for making the bevel gear chamber below the peeling bowl. After the concrete has stood in the mold for several hours and has hardened sufficiently, the mold is inverted and the inner surface of the bowl is roughened with a steel brush.—*Concrete Age.*



CONCRETE POTATO PEELER

Work Among Southern Farmers

As a result of the teaching of the methods of the Department for scientific farming, farmers throughout the country have increased their yields. The demonstration work among southern farmers has shown excellent results and progressive growth. Organized in 1904 for the purpose of fighting the boll weevil in Texas, this work has now extended to all the southern states. The boll weevil has been fought progressively, and where the farmers have followed the instructions of the agents of the Department an average crop of cotton has been produced in spite of the weevil, and statistics show that on the other hand where planters have not followed the instructions a crop failure has resulted. This is conspicuously true in the alluvial sections of Texas, Louisiana, and Mississippi. The methods advocated are being adopted by farmers in the boll-weevil-infested territory and are fast being recognized as the best means yet presented of raising a crop of cotton in spite of the boll weevil. This means the restoration of confidence and credit and prevents the abandonment of farms and emigration of labor to other fields. From 1904 to the present time the agents in this line of work have been increased from 1 to 450, and the demand is growing. More than 75,000 farmers are receiving direct instruction on their farms.

Potash Salts: Light on an International Controversy—I*

Uses and Occurrence of Potash in the United States

By W. C. Phalen

INTRODUCTION.

The many inquiries that have come to the Geological Survey for official information regarding American sources of potash have rendered advisable the publication of the available data on this subject. Chapters on potash salts were published in the annual reports on mineral resources of the United States for 1887 and 1904. The more important statements in these summaries are here republished and expanded in the light of later observations and other information procured by the Survey geologists, chemists, and statisticians.

Potash salts are used extensively in the United States. They are essential to numerous industries that are vitally connected with the welfare of the American people—the most notable being the fertilizer industry. They are used also in the manufacture of glass, in certain kinds of soap, in some explosive powders, and in the chemical industries, including the manufacture of alum, cyanides, bleaching powders, dyestuffs, and other chemicals, among which are arsenite of potassium, bromide of potassium, chlorate of potassium, permanganate and manganate of potassium, nitrate of potassium, and silicate of potassium.

DOMESTIC POTASH INDUSTRY.

Practically all the potash salts of mineral origin consumed in the American industries at present are imported from abroad, chiefly from Germany. There was a time in the history of the potash industry, however, when the United States produced a large part, if not all, of the potash it consumed. The burning of wood and the lixiviation of the resulting ash to extract the potash, though of minor importance so far as the monetary value of the product is concerned, is one of the oldest of the purely chemical industries in this country. Cognizance was taken of it in the census reports as early as 1850, so that data are available for comparing the condition of the industry for each decade since that year. In the following table are given the quantity and value of potash produced in the United States from 1850 to 1905:

Potash salts produced in the United States, 1850 to 1905.[1]

Census.	Number of Establishments.	Product. Quantity.	Product. Value.	Average Price per Pound.
		Pounds.		
1850	509	....	$1,401,533	....
1860	212	....	538,550	....
1870	105	....	327,671	...
1880	68	4,571,671	232,643	$0.051
1890	75	5,106,989	197,597	0.039
1900	[2]67	3,864,766	178,180	0.049
1905	[2]39	1,811,087	104,655	0.058

[1] Munroe, C. E. Bull. 92, Census of Manufactures, Bur. Census, 1905, p. 38.
[2] Includes establishments engaged primarily in the manufacture of other products.

According to C. E. Munroe the figures given above show a constant decrease in the total value of the potash produced in this country since 1850 and a steady decrease in the quantity of the product since 1890.

"This seems quite reasonable, in consideration of the destruction of the forests during recent years and the resulting decrease in the quantity of ashes readily available for the manufacture of potash; also in consideration of the decrease in the native fertility of the soil, with which has come an inclination to return potash to the soil as it occurs in the ashes rather than to extract and market it; and also in consideration of the cheapening of soda or hard soaps and increased facilities for bringing them to agricultural communities, whereby the temptation to extract potash from ashes for the manufacture of potash or soft soaps is lessened. These causes, combined with the comparative cheapness of foreign potash, tend to destroy the domestic industry. The data given in the above table indicate that the industry is a waning one and that it may come to be of so slight importance as not to warrant separate consideration in subsequent censuses, unless other causes, recently set in operation, shall revive it in another form."

IMPORTATION OF POTASH SALTS.

The potash industry has not been revived in the United States thus far, and the great bulk of the potash salts now used are imported. The following table shows the magnitude of the importation of potash salts for the years 1900, 1905, and 1910.

Imports of potash salts for the calendar years 1900, 1905, and 1910, in pounds.[2]

(Figures from Bureau of Statistics.)

	1900 Quantity.	1900 Value.	1905 Quantity.	1905 Value.	1910 Quantity.	1910 Value.
	Pounds.		Pounds.		Pounds.	
Chlorate	1,243,612	$68,772	....	....	....	....
Chloride	130,175,481	1,976,604	214,207,064	$3,326,478	381,873,875	$5,252,373
Nitrate (Crude and refined)	10,545,392	276,664	9,911,534	304.596	11,496,904	333,854
All other, including carbonate (crude and refined), bicarbonate, caustic (crude and refined), chromate and bichromate, cyanide, hydriodate, iodide, iodate, permanganate, prussiate (red and yellow), sulphate (crude and refined)	54,904,088	1,407,398	82,935,532	1,891,081	116,820,873	2,777,396
Total	196,868,573	$3,729,343	307,054,130	$5,522,155	510,191,652	$8,363,623
Increase	....	....	110,185,573	1,792,812	203,137,522	2,841,468
Percentage of increase	....	....	55.96	48.07	66.15	51.45
Kainite, "kyanite," and kieserite, and manure salts[3]	530,605,120	$1,508,217	890,908,360	$3,116,884	1,288,190,390	$3,251,511

[2] This table is based on total imports for the calendar year, not, as nearly all the import tables in this volume, on imports for consumption for the calendar year.
[3] These figures are for the fiscal years.

THE CHEMICAL MANUFACTURES IN THE UNITED STATES DEPENDENT ON IMPORTED POTASH SALTS.

Potash.

Under the head of potash are included potassium carbonate and caustic potash. Potassium carbonate is made from potassium chloride by the LeBlanc process, in the same way as soda ash from salt, but the ammonia process can not be employed, because the acid carbonate of potassium ($KHCO_3$) is soluble in ammoniacal solutions and does not precipitate. The material is sold in the trade under the name potash or pearlash and is used chiefly in the glass industry, in the manufacture of caustic potash, and in the manufacture of chromates of potassium. A considerable quantity is bought by soap makers and causticized, the solution being used for soft soaps.

Caustic potash (KOH) is made in the same way as caustic soda. It is much more deliquescent than the corresponding sodium compound and is generally made where it is to be used. In soap making it was formerly customary to saponify the fat with caustic potash and then to add common salt. An interchange between the potassium and sodium took place, the result being a hard sodium soap. But as soda is now cheaper than potash and yields a hard soap directly, potash soaps are used only for special purposes.

The consumption of potash or pearlash in the glass industry of the United States at the census of 1890 was 2,544,978 pounds, valued at $135,047, and at the census of 1900, 4,406,211 pounds, valued at $186,047. The percentages of increase in quantity and value are, respectively, 73 and 38. The quantity of potash used in the soap industry at the census of 1905 was 4,453,800 pounds, valued at $191,933, but this does not include the potash produced and consumed in the same establishments in the manufacture of soft soap. Glass and soap making are two of the industries in which the largest quantities of potash, as such, are used.

The following table shows the imports of potash and ashes for three years—1904, 1905, and 1910:

Imports of potash and ashes, 1904, 1905, and 1910.

Year Ending June 30.	Imports of Bicarbonate of Potash. Quantity.	Imports of Bicarbonate of Potash. Value.	Imports of Carbonate of Potash. Crude or Black Salts. Quantity.	Crude or Black Salts. Value.	Refined. Quantity.	Refined. Value.
	Pounds.		Pounds.		Pounds.	
1904	98,769	$4,778	8,196,872	$224,396	13,586,306	$397,104
1905	76,988	4,594	7,166,560	218,816	13,687,083	440,139
1910	334,300	16,683	8,407,373	263,643	9,036,267	308,917

Year Ending June 30	Imports of Caustic or Hydrate of Potash. Not Including Refined, in Sticks or Rolls. Quantity.	Not Including Refined, in Sticks or Rolls. Value.	Refined, in Sticks or Rolls. Quantity.	Refined, in Sticks or Rolls. Value	Imports of Ashes (Wood) and Lye of, and Beet-root Ashes (Value).
	Pounds.		Pounds.		
1904	4,810,993	$194,889	38,048	$4,879	$62,641
1905	5,289,804	217,041	23,313	2,587	60,718
1910	8,785,491	358,855	141,490	11,095	60,220

Alums.

In the manufacture of potash alum

$(K_2SO_4.Al_2(SO_4)_3.24H_2O)$,

large quantities of potassium sulphate are used. On the addition of the potassium sulphate to the sulphate of alumina, the potash alum crystallizes out in extremely pure form. Alum is extensively used in the dyeing industry as a mordant and by paper makers and leather dressers. A small quantity is used in medicine. The following table gives the quantity and value of potash alum manufactured in the United States at the censuses of 1900 and 1905. The figures for 1910 are not yet available:

Potash alum manufactured in the United States, 1900 and 1905.

	Quantity.	Value.
	Pounds.	
1900	14,200,393	$215,004
1905	10,307,154	156,148

Cyanides and Derived Compounds.

The class of cyanides comprises potassium cyanide, or white prussiate of potash; sodium cyanide and other simple cyanides, including "cyan-salt," a mixture of potassium and sodium cyanides; potassium ferrocyanide (yellow prussiate of potash); potassium ferricyanide (red prussiate of potash); there are also the cyanates and ammonium and potassium sulphocyanates, etc.

Potassium cyanide (KCN) is generally made by fusing potassium ferrocyanide with potassium carbonate until the evolution of gas ceases. The following is the reaction:

$$K_4Fe(CN)_6 + K_2CO_3 = 5KCN + KCNO + CO_2 + Fe.$$

The metallic iron that is produced sinks to the bottom of the crucible, and the fused mixture of cyanide and cyanate is run off. The addition of powdered charcoal reduces part of the cyanate to cyanide. The product thus prepared is pure enough for many purposes. The commercial salt always contains cyanate and carbonate and is sold in various grades, depending on the purpose for which it is to be used. The best quality contains about 98 to 99 per cent KCN, but ordinary grades contain only 65 to 70 per cent. It is a very powerful reducing material when heated with reducible substances, and hence its use as a flux. It is extremely poisonous, either when taken internally or when introduced directly into the blood. It is extensively employed in electroplating as the solvent in the bath, forming soluble double cyanides with gold, silver, copper, and other metals. It is also used as a flux in assaying and metallurgy. Its greatest use at the present time is for the recovery of gold from low-grade ores and the tailings of other reduction processes. A weak solution is used to dissolve the gold, forming aurous potassium cyanide (AuCN.KCN). It was formerly used in photography for "fixing" the image, but for this purpose it has been largely replaced by sodium thiosulphate.

Potassium ferrocyanide ($K_4Fe(CN)_6.3H_2O$), also called yellow prussiate of potash, is made by fusing together potassium carbonate, iron borings, and nitrogenous organic matter of any kind, such as horn, hair, blood, wool waste, and leather scraps. The material in its pure form is produced in splendid large lemon-yellow crystals. It is not poisonous. It is largely used for making Prussian blue; in calico printing and in dyeing; for case-hardening iron; for making potassium cyanide and ferricyanide; and to a small extent in explosives, and as a chemical reagent.

Potassium ferricyanide, or red prussiate of potash (K_3FeCN_6), is usually made by passing chlorine gas into a solution of the ferrocyanide until ferric chloride no longer forms a precipitate, but produces only a brown color in the liquid. It may also be made by exposing the dry powdered ferrocyanide to chlorine until a test portion dissolved in water gives nothing but a brown color, with ferric chloride. With ferrous

* Reprint of a bulletin issued by the U. S. Geological Survey.
[1] Op. cit. pp. 38 et seq.

salts, it gives the blue pigment, Turnbull's blue. Its solution with caustic potash is a powerful oxidizing liquid, and as such is used in calico printing for a "discharge" on indigo and other dyes. It also forms part of the sensitive coating of blueprint papers. It has been recommended for use with potassium cyanide solution in gold extraction.

The following table shows the magnitude of the cyanide industry in the United States at the censuses of 1900 and 1905. The figures for the census of 1910 are not yet available.

Potassium cyanide manufactured in the United States, 1900 and 1905.

	1900	1905	Increase.	Per Cent of Increase.
Quantity, pounds	8,460,989	11,196,318	2,735,329	32.3
Value	$1,595,505	$1,710,823	115,318	7.2
Value per pound	$0.189	$0.153	...	....

Fertilizers.

The class of fertilizers comprises numerous chemical compounds, among them the so-called complete fertilizers, which consist of superphosphate of lime, potash salts, and ammoniacal compounds or nitrates. The following table gives the quantity and value of complete fertilizers manufactured in the United States at the censuses of 1900 and 1905, together with the amount and percentage of increase. The figures for the census of 1910 are not yet available:

Complete fertilizers manufactured in the United States, 1900 and 1905.

	1900	1905	Increase.	Per Cent of Increase.
Quantity tons[1]	1,478,826	1,603,847	125,021	8.5
Value	$26,318,995	$31,305,057	$4,986,062	18.9

[1] The ton used in this report is the short ton = 2,000 pounds, except where otherwise stated.

The following table gives the quantity and value of the principal potash materials used in fertilizers in the United States at the two censuses cited, with the amount and percentage of increase, the figures for the census of 1910 not being available. This table includes only the materials used in the principal establishments in the United States.

Principal potash materials used in fertilizers in the United States, 1900 and 1905.

	1900	1905	Increase.	Per Cent of Increase.
Kainite:				
Quantity, tons	54,700	190,498	135,708	248.3
Value	$520,833	$1,891,073	$1,370,240	263.1
Potash Salts:				
Quantity, tons	....	122,107	... .	.. ...
Value	$3,098,400	$3,606,701	$508,301	16.4
Nitrate of Potash:				
Quantity, tons	884	1,160	276	31.2
Value	$32,156	$39,039	$6,883	21.4
Wood Ashes:				
Quantity, bushels	....	47,088	... ...	....
Value	....	$2,050	....	....

Bleaching Materials.

The class of bleaching materials includes, among a great many other chemicals, potassium bisulphite. The following table gives the quantity and value of bisulphites manufactured in the United States at the censuses of 1900 and 1905, with the amount and percentage of increase, the figures for the census of 1910 not being available. Potassium bisulphite forms a very small part of the total.

Sodium, potassium, calcium, and other bisulphites manufactured in the United States, 1900 and 1905.

	1900	1905	Increase.	Per Cent of Increase.
Quantity, tons	1,461	6,223	4,762	325.9
Value	$34,486	$110,155	$75,669	219.4

Chemicals Produced by the Aid of Electricity.

Among the chemicals produced by the aid of electricity are potassium chlorate and potassium hydroxide. The following table gives the quantity and value of the potassium salts made electrolytically at the censuses of 1900 and 1905, with the amount and percentage of increase, the figures for 1910 not being available:

Potash salts made electrolytically in the United States, 1900 and 1905.

	1900	1905	Increase.	Per Cent of Increase.
Quantity, tons	1,900	3,908	2,008	105.7
Value	$80,097	$200,008	$119,911	149.7

Dyestuffs.

Potash salts enter into the dyeing industry chiefly in the form of alum. The production of alum has already been given and will not be repeated here. Potassium sulphide is frequently used to improve the "fire" in vermilion. Potassium bichromate is extensively used in the manufacture of chrome green.

Explosives.

Potash salts in the form of nitrate enter into the manufacture of gunpowder. The term "gunpowder" generally includes the nitrate-sulphur-charcoal combination used in blasting as well as that used in guns, and for the last fifty years it has included the blasting powder made with nitrate of soda as well as that made with nitrate of potash. Potassium nitrate is also a constituent of some of the higher-grade explosives tested and listed by the Bureau of Mines as "permissible explosives." Potassium nitrate is made by the double decomposition of sodium nitrate with potassium chloride, the former being largely imported from Chile. The reaction ($NaNO_3 + KCl = NaCl + KNO_3$) is very simple. The following table gives the quantity and cost of nitrate of potash used in the explosives industry in the United States in the years 1900 and 1905, the figures for 1910 not being available:

Potassium nitrate used in the manufacture of explosives in the United States, 1900 and 1905.

	1900	1905
Quantity, tons	3,315	4,114
Value	$270,186	$308,644

General Chemicals.

Under the heading of general chemicals, potash enters into the composition of a host of substances. Some of these are arsenite of potassium, used in the dyeing industry; bromide of potassium, used in photography and medicine; chlorate of potassium, used in fireworks, matches, and aniline colors; chromate of potassium, used in dyeing and electricity; manganate and permanganate of potassium, used in dyeing and bleaching, in disinfectants, and in medicine; silicate of potassium, used in making ordinary yellow soaps, as a fixative for pigments in calico printing, as a vehicle for pigments in fresco painting, for rendering cloth and paper non-inflammable, etc.; cream of tartar; and argols.

THE DEPOSIT OF POTASH SALTS NEAR STASSFURT, GERMANY.[1]

Discovery.

Although potash occurs in many forms and places in the United States, as described in a subsequent part of this report, up to the middle of the nineteenth century wood ashes constituted practically the sole source of supply. In 1857 a shaft which the German government had been sinking for about five years near Stassfurt reached a depth of approximately 1,100 feet, but in the meanwhile had passed through a deposit of so-called "Abraumsalze," or refuse salts, consisting largely of compounds of potash and magnesia, then considered worthless.[2] This deposit is now and long has been the chief source of potash and the potassium salts of commerce. It is estimated by C. Ochsenius[3] that the German deposit of potash salts may last over 600,000 years.

Theory of Occurrence.

The theory developed by Ochsenius for the occurrence of salts at Stassfurt is briefly as follows: A deep bay is imagined, connected with the sea by a narrow and shallow channel, but otherwise cut off from oceanic circulation by a bar. If no large streams enter the bay, the outflow from it will be small, but sea water can enter freely to offset the losses due to evaporation. Evaporation of course takes place only at the surface, and the upper layers, thus becoming denser, must sink, producing a saline concentration at the bottom. In this manner, being continually supplied with new material from without, the salinity of the bay will gradually increase until saturation is reached and the deposition of salts begins. So long as salt water can enter the bay this process will continue, and the depths of the basin will in time become a solid mass of salt, covered with a sheet of bittern. If, meanwhile, an elevation of the land takes place separating the bay completely from the ocean, evaporation may proceed to its limit and the mother liquor, containing the more soluble salts, including the potash salts, will deposit its contents in more or less well-defined layers above the salt at the bottom. In the Karaboghaz and other bays on the eastern shore of the Caspian Sea the process of saline concentration can now be observed in actual operation, but only part of the programme has yet been performed.

This theory of Ochsenius is not the only one possible to account for the concentration of salts. It must be remembered that salt is not deposited from sea water until it has been concentrated to about one-tenth of its original volume. Suppose, now, a large sheet of water, in whose bottom there is a deep depression, be cut off from the ocean by any change in the level of the land. The water in the depression will gradually become concentrated and its saline load will tend to accumulate there. A layer of salt will thus form of much greater thickness than if evaporation took place over a comparatively level bottom, and if the surface area of the depression is small in comparison with that of the original sheet of water the depth of the deposit may be very great. Such a deposit might also be reinforced by leaching from other salt beds or from diffused salts in adjacent areas—a process which is now going on in the valley of the Dead Sea and in certain lakes of the arid region of the western part of the United States.

Salts Deposited.

In the Stassfurt or, more properly, the Magdeburg-Halberstadt region the order of deposits, from the surface downward, is as follows:

1. Drift, about 8 meters (26 feet) thick.
2. Shales, sandstones, and unconsolidated clays of varying thickness.
3. Younger rock salt, thickness very variable, sometimes missing.
4. Anhydrite, rarely lacking, 30 to 80 meters (98 to 262 feet) thick.
5. Salt clay, average thickness 5 to 10 meters (16 to 33 feet), very rarely absent.
6. The carnallite zone, from 15 to 40 meters (49 to 131 feet) thick. At Douglashall a layer of rock salt intervenes between the carnallite and the clay. In parts of the field kainite overlies the carnallite, is itself overlain by "sylvinite" or "hartsalz," and that in turn by schoenite. These subzones are often missing.
7. The kieserite zone.
8. The polyhalite zone.
9. Older rock salt and anhydrite. Nos. 7, 8, and 9 have a total thickness ranging from 150 to perhaps 1,000 meters (492 to 3,280 feet). The anhydrite forms layers, averaging 7 millimeters (0.27 inch) thick, separating the salt into sheets of 8 or 9 millimeters (0.31 or 0.35 inch). These layers have been interpreted as annual deposits, due possibly to seasonal variations in temperature or to alternating drought and rain. If this supposition is correct, a Stassfurt salt bed 900 meters (2,953 feet) thick would require 10,000 years to form.
10. Anhydrite and gypsum.

The above is a complete record of the saline deposition at Stassfurt, ranging from the calcium sulphate at the bottom to the mother liquor or carnallite salts at the top. Above the carnallite a protecting layer of clay was laid down, and after that probably a new accession of sea water began the formation of a second series of beds, which, however, are regarded by some as having resulted from the re-solution and redeposition of older beds.

In the Stassfurt deposits more than 30 saline minerals have been found, some of which are regarded as primary and others as derived from the primary minerals by secondary reactions. A few are simple salts but the bulk are double compounds. Chlorides, sulphates, and borates are most common, but the mineral kainite contains both the chloride and sulphate radicles. The sulphates found at Stassfurt are as follows:

Anhydrite ....$CaSO_4$.
Gypsum ....$CaSO_4.2H_2O$.
Glauberite ....$CaSO_4.Na_2SO_4$.
Polyhalite ....$2CaSO_4.MgSO_4.2H_2O$.
Krugite ....$4CaSO_4.MgSO_4.K_2SO_4.K_2SO_4.2H_2O$.
Kieserite ....$MgSO_4.H_2O$.
Epsomite ....$MgSO_4.7H_2O$ (reichardtite).
Vanthoffite ....$MgSO_4.3Na_2SO_4$.
Bloedite ....$MgSO_4.Na_2SO_4.4H_2O$ (astrakanite).
Loewite ....$MgSO_4.Na_2SO_4.2\frac{1}{2}H_2O$.
Langbeinite ....$2MgSO_4.K_2SO_4$.
Leonite ....$MgSO_4.K_2SO_4.4H_2O$.
Picromerite.........$MgSO_4.K_2SO_4.6H_2O$ (schoenite).
Aphthitalite ....$K_3Na(SO_4)_2$ (glaserite).
Kainite ....$MgSO_4.KCl.3H_2O$.

Little is heard of these salts, except of kainite, and this is of great importance. It is readily soluble in water, and, most of its potash being immediately available as plant food, it is used extensively as a fertilizer.

The chlorides found in the Stassfurt region are as follows:

Halite or rock salt..$NaCl$.
Sylvite[1].............KCl.
Douglasite ....$K_2FeCl_4.2H_2O$.
Carnallite ....$KMgCl_3.6H_2O$.
Tachhydrite ....$2MgCl_2.CaCl_2.12H_2O=3(RCl_2.4H_2O)$.
Bischofite ....$MgCl.6H_2O$.
Rinneite ....$FeCl_2.3KCl.NaCl$.

As already stated these chlorides represent the con-

[1] Largely compiled or quoted from Clarke, F. W., Bull. U. S. Geol. Survey No. 330, 1908, pp. 176 et seq.
[2] Potash in agriculture, The German Kali Works, p. 5.
[3] Die Kunstdurnger Industrie, vol. 11, No. 9.

[1] "Sylvinite" is a mixture of sylvite and rock salt; "Hartsalz" contains these substances together with kieserite.

centration of the mother liquors in the carnallite zone. They were the most soluble compounds existing potentially in the sea water, and with the kainite ($MgSO_4.KCl.3H_2O$) they were among the last substances to crystallize. The chemistry of the deposition and the interreaction of these substances is most complex, and the literature, mostly in German, is widely scattered.

It must not be supposed that these zones of deposition are regularly and completely separated, nor even that they represent in any close degree the products observed in the artificial evaporation of sea water or brine. In the latter case a moderate quantity of water is concentrated by itself; at Stassfurt more water was continually added from the ocean. On the one hand, calcium sulphate is deposited almost wholly at one time; on the other, new quantities were precipitated so long as the evaporating bay retained its connection with the sea: In the salt pan gypsum ($CaSO_4.2H_2O$) forms a bottom layer before salt begins to separate out; at Stassfurt anhydrite ($CaSO_4$) is found in greater or less amount through all the zones, and so also is salt (NaCl). When a shallow lake or isolated lagoon evaporates, the artificial process is closely paralleled, but a concentration, with continuous replenishment, lasting for thousands of years, is a very different thing. The principles are unchanged, the broad outlines remain the same, but the details of the process are greatly modified.

(To be continued.)

The Crane Collection of the New York Zoological Park*

How Cranes are Kept in a Great Paddock

By Lee S. Crandall, Acting Curator of Birds

AMONG the many groups of birds possessing ornate qualities, few are so hardy in captivity, or thrive with such meager care, as that formed by the cranes. It is true that the ornamental value of these birds is not, as yet, fully recognized in America, although they are kept extensively on European estates; still, large numbers of cranes are brought to this country annually, and there is no doubt that their popularity is steadily increasing.

Captive cranes are, perhaps, of greatest interest when enjoying their liberty on an extensive range; but the aviculturist who is truly interested in them will wish to confine his specimens where they can be kept under closer observation. For this purpose, a plot of two or three acres of ground should be selected, and inclosed by a fence which need not exceed five feet in height. The crane paddock in the New York Zoological Park is so nearly an ideal home for most of the members of the society's excellent collection that a description of it may be of interest.

The paddock is about 150 feet square, and is surrounded by an ornamental fence, averaging four feet in height. While most of the inmates are pinioned, they can leap this fence easily when alarmed, although they never attempt to do so under ordinary circumstances. The inclosure is well carpeted with grass, which is kept closely cropped during the summer months. A number of large shade trees is included within its limits, besides several clumps of shrubs, which afford seclusion to any birds which desire it. One of the most valuable features, however, is a little stream that traverses the entire length of the paddock. The birds derive an infinite amount of pleasure from wading and probing about in the little pools, and the effect produced is certainly most pleasing to onlookers. A small shed is provided for use during severe weather. The Manchurian, whooping, white-necked, sarus and sandhill cranes are confined here, while the others are divided between the wild fowl inclosure and the ostrich house.

Few birds require so little attention as the cranes. Their chief food is grain, but occasional mice, frogs, fish or chopped meat are always appreciated and become a necessity during cold weather. Many of the species are perfectly hardy, provided healthy specimens are secured. If acquired in the spring and given an opportunity for becoming acclimated, they will live in the open through the winter, happily and well, requiring only that they receive their food and water regularly. Some protection from wind should be provided, of course; and it is well to place within the inclosure a small shed, although it is safe to say that the birds will use it rarely, unless driven in.

* *Zoological Society Bulletin.*

THE CROWNED CRANE (BALEARICA PAVONINA)

A surprising assiduity in the search for worms and tender roots is a failing which may become serious, and result, especially after rain, in the uprooting of patches of turf. Generally this can be checked effectively either by confining the birds for a short time following showers, or by covering their favorite feeding grounds with small branches.

The greatest difficulty in the maintenance of a large collection of cranes is found in the erratic disposition of the birds. A number may live together for months in perfect harmony; but just as the collector begins to congratulate himself on their good behavior, one may be found with an eye missing, or with its skull pierced! It really is not safe to associate the larger and smaller species in a permanent group, unless the inclosure be very large, or the number of birds very small. Great care must be taken in introducing strange birds to a flock already well settled. The new-comers are certain to be subjected to a more or less harrowing inspection by the original inmates, who consider them as nothing more than intruders. The strangers will be persistently driven from pillar to post for some days, and will be fortunate indeed if they escape without some injury. The safest way to establish a crane family is to place all of the intended members in the inclosure at the same time; then none can use the prestige of previous occupancy as an excuse for tyranny. Brought together in this abrupt manner, the birds will soon learn to tolerate one another.

The Order Gruiformes includes, besides the true cranes, six groups of remarkable birds, such as the sun-bitten, the kagu and the seriema, which have been assigned to this order in lieu of a better place. Their structures are confusing, and their relationships obscure. The birds with which we are to deal here are divided into nineteen species, which form the Suborder Grues, and are cosmopolitan, with the exception that none are found in South America. Asia is particularly fortunate in being the home of seven species. Some of these birds are fairly easy to obtain alive; but most of them are far from common in captivity, and a few are seen rarely, if ever.

At present, nine species, all of which possess characters of interest, are included in the Zoological Park collection. Several of these are members of the genus *Grus*, which includes the three species of North American cranes.

The Sandhill crane (*G. mexicana*) still is fairly common on the plains of western North America, where there is little cover to shelter skulking enemies. This is the most numerous of our cranes, and therefore the best known. It is rather small, as compared with most of its relatives, its length being about forty-six inches; its color is a uniform slaty gray, with the bare skin of the crown reddish. In captivity this crane becomes delightfully tame, and is very hardy and long-lived. This species nested in the Zoological Park in 1904 and 1905, but the eggs proved infertile on both occasions.

The little brown crane (*G. canadensis*) is a very close relative of the sandhill, and is distinguished by its smaller size, and shorter tarsus. It breeds through Arctic America and Siberia, migrating to the western United States and Mexico for the winter. The inaccessibility of its habitat explains its long confusion with the sandhill, and also accounts for its scarcity in captivity. The species is not represented in the collection at present.

The third and rarest of the American Grues is the beautiful whooping crane (*G. americana*). It is pure white in general color, but the primaries are black and the bare portions of the head are reddish, bordered posteriorly by a patch of blackish feathers. The secondaries are curved downward and arch gracefully over the tail. No doubt, the great scarcity of this bird is due, in part, to reckless shooting, but it seems probable that the invasion of settlers into its breeding grounds in the great middle territories of Canada, and the increasing cultivation along its migration route through the Mississippi Valley, are hastening the inevitable extermination of this finest of American birds. The numerical condition of a species in the wild state generally bears an exact ratio to the frequency with which it is met in confinement; it is probable that the number of whoopers in captivity could be counted on the fingers of one hand. It is unfortunate that this splendid crane cannot be induced to follow the example of the wood duck, which is willing to save itself

THE BEAUTIFUL WHOOPING CRANE (G. AMERICANA)

THE PARADISE CRANE (TETRAPTERYX PARADISEA)

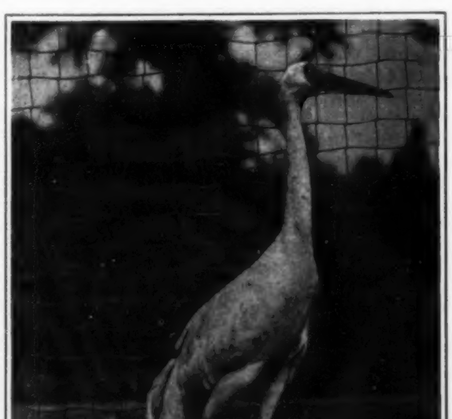
from extermination by breeding freely in captivity. Most of the wood ducks seen in American collections are birds bred in Europe! But cranes of most species are bred only on rare occasions, and then with great difficulty, so there seems little to hope for from this source. The Zoological Society is fortunate enough

THE LITTLE BROWN CRANE (G. CANADENSIS)

to possess a very fine whooper and it is hoped that he will be blessed with the usual longevity of his race.

The Manchurian crane (*G. japonensis*) is one of the most strikingly handsome of all the group. It is very uncommon in captivity, and now for the first time is represented in the collection. Its general color is white, as in the whooper, but in this case the arched and pointed secondaries are black, and the primaries white. A slaty-black band extends down each side of the neck, the two joining on the nape. The bird measures about fifty inches from tip to tip when fully extended. It ranges from eastern Siberia to Corea and Japan; in the last-named island it was formerly held sacred and was allowed to be hawked by the nobles only. The cranes depicted on Japanese screens are usually of this species.

Next in systematic order comes the Asiatic white crane (*Sarcogeranus leucogeranus*). It is considerably smaller than the foregoing, and is found from southeastern Europe to China and Japan. It is white, the primaries black, and the head bare and reddish in color. The immature birds of this species, as well as those of the whooper, have the white plumage infused with cinamon-buff, giving them a remarkable appearance. This is one of those species most easily obtained alive, and is brought to this country in some numbers. It is quite hardy and easily tamable. The



THE ASIATIC WHITE CRANE (SARCOGERANUS LEUCOGERANUS)

specimen in the Zoological Park, however, has a temper so irascible that he cannot be approached with impunity, and is no longer allowed the freedom of the large paddock.

Of the larger cranes, the sarus (*Antigone antigone*), an Indian species, is most commonly seen in collections. It is the tallest of the order, sometimes attaining a length of sixty inches. Its color is a handsome French gray, the overhanging secondaries closely approaching white; the head and the upper part of the neck are bare and reddish, the gray feathers of the lower neck being bordered above by a band of white. The sarus is a most vigorous bird and inclined to be dangerous when associated with smaller and weaker species; its height, strength, and an uncertain temper make it a companion to be feared.

One of the rarities of the collection is the white-necked crane (*Pseudogeranus leucauchen*). This is a medium-sized bird, of a beautiful shade of gray, with the throat and the posterior portions of the head and neck white, the gray of the shoulders commencing at a sharp line. The anterior part of the crown is bare and reddish. The long and falcate secondaries, which are very light in color, are curved less abruptly, and hence more gracefully than in some other species. It is found in eastern Siberia, Corea, and Japan, and is very seldom imported alive. In captivity it is quiet and docile, showing a most pleasing absence of the pugnacity so frequent among its congeners.

A crane of unusual and handsome appearance is the Stanley or Paradise (*Tetrapteryx paradisea*). It is a bird of fair size, ranging throughout the southern portions of Africa, where it is fairly common. In color it is a uniform slate, becoming practically white on the head, the feathers of which are so lengthened as to give it a strangely swollen effect. The drooping secondaries reach the height of their development and beauty in this species. The Paradise is a very desirable bird for the aviculturist, for both its docility and beauty; it is imported very infrequently.

In captivity, the crane most frequently seen is the dainty Demoiselle (*Anthropoides virgo*). It is the smallest of the family, as well as the most widely distributed, since it breeds in southern Europe and central Asia and spends the winters in southern Asia and northern Africa. Its general color is the conventional gray, set off by the elongated black feathers of the breast, those over the eyes being drawn out into lateral tufts of silky white. The demoiselle is brought to the United States each year in scores, for the demand for it is great. Its small size reduces its capacity for mischief, even if its usually even temper should allow it to fall from grace; its engaging ways excite the admiration of all who have opportunity to observe them. This crane is willing to breed in confinement, and has done so in this country on at least two occasions.

The crowned crane (*Balearica pavonina*) of western Africa, differs from all the others in the possession of an occipital patch of straw-like plumes, from which it derives its name. It is a handsome bird, the blackish slate of its body plumage being contrasted by white wing-coverts and chestnut secondaries. The sides of the head are bare and colored white above, and pink below; there are two small, pinkish wattles on the throat. This crane is uncommon in America, very few having been imported. It is long-lived and attractive, and not so determined a root digger as most others; but its temper, among the society's specimens, at least, is decidedly choleric.

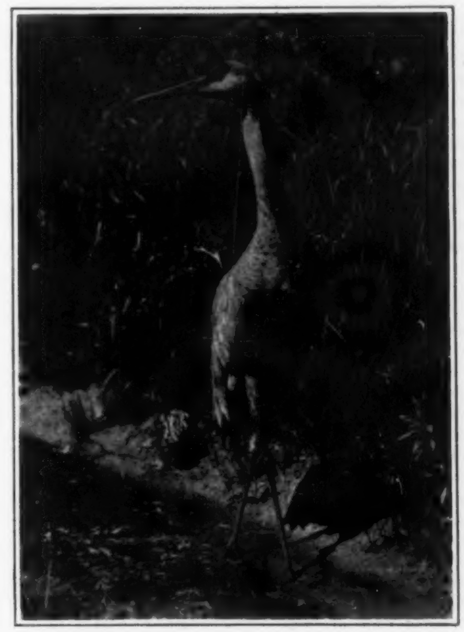
All of the cranes nest on the ground, usually in marshes or on open plains, forming their nests of grass and rushes. The eggs are generally whitish or buff in color, double-spotted with yellow or brown blotches, and commonly two in number.

Young cranes are most precocious, being able to run about quite freely soon after hatching. For a short time before the youngsters commence to forage for themselves, their food consists mainly of insects brought to them by the old birds. The parent birds are very devoted to their offspring, caring for them with great solicitude and guarding them valiantly against intruders. If an attempt to breed cranes in captivity is to be made, a large, grassy run should be provided for the exclusive use of the family, as anxiety for the welfare and safety of the chicks is apt to make the parents over zealous in the treatment of the others in the same corral.

An adult crane is a formidable antagonist, not to be despised even by a man. Frequently some members of the collection are so savage that they must be isolated, and the keeper must then continually guard himself against attack. The crane stretches his long neck to the uttermost, and without hesitation makes frantic thrusts with his powerful beak, so swift and certain that the eye can scarcely follow the movement.

An interesting characteristic of cranes is their habit of indulging at frequent intervals in grotesque dances, which may be performed by an individual, or by a group in graceful unison. The leader starts off leaping and bowing, with broad wings widely expanded; now seizing a leaf or bit of stick, now tossing it aside in capricious disdain. The spirit of the dance is infectious, and instantly the enclosure is a turmoil of leaping, bobbing birds, each striving to outdo the others in extravagance of gesture and motion.

Most of the species are provided with lusty voices, which they delight to use with great freedom. How-



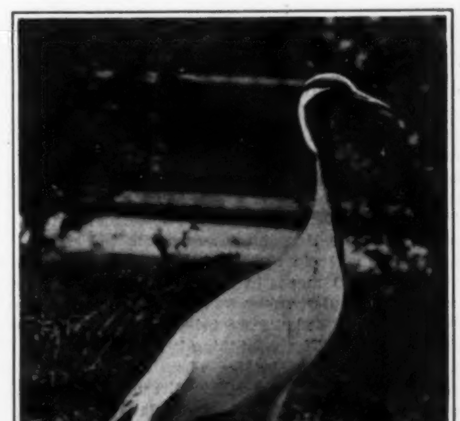
THE SANDHILL CRANE (G. MEXICANA)

ever, the tones, which are clear and trumpet-like, are far from disagreeable, and detract nothing from the performer's eligibility to a favored place in the list of captives.

Animal Husbandry

Experiments in breeding carriage horses has been continued in Colorado and Morgan horses in Vermont. The Colorado stud now has 71 animals, the Vermont stud 30. Several additional zebra-ass hybrids have been produced; those now in their second year are larger than their dams, though not as large as their sires. That beef production may be a profitable business in the South when the cattle tick has been eradicated is shown by feeding experiments in Alabama, now in progress for six years. Feeding experiments with poultry indicate that fowls will not readily eat a ration containing more than 30 per cent of cotton-seed meal, and no harmful effects have resulted from such a feed. Studies of the egg trade show that better methods of handling will greatly reduce the losses.

The Secretary of Agriculture suggests that in order to secure the 2,000 or 2,500 horses now needed by the army every year 100 stallions should be owned by the Government, and arrangements should be made for securing mares of proper type, the War Department to have an option on the purchase of the foals.



THE DEMOISELLE CRANE (ANTHROPOIDES VIRGO). THE SPECIES MOST FREQUENTLY SEEN IN CAPTIVITY

New Theories of the Evolution of Stellar Systems

Successors of Kant and Laplace

By F. W. Henkel, B.A., F.R.A.S.

During the last few years the researches of Chamberlin, F. R. Moulton and See on the evolution of our system have greatly shaken the faith of astronomers in Laplace's well-known Nebular Hypothesis. More than a century ago Laplace, who more completely than any other had worked out the consequences of Newton's theory of gravitation to the satisfactory explanation of almost every known feature of the motions of the planets, developed a hypothesis previously proposed by Swedenborg, Wright, and the great philosopher Kant. The solar system consists of a number of bodies arranged in an orderly manner, all moving in nearly circular paths round the central body, these paths being all nearly in the same plane, and their motion in the same direction, while there is a fairly regular progression of distances from the sun (Bode's Law), and the bodies are either spherical or spheroidal. These features are by no means a necessary consequence of gravitation, and seemed to imply an original connection or common origin. Laplace supposed that at one time the matter now forming the sun, earth and other planets was in the form of an intensely hot gas, perhaps hotter than the sun is now. This mass was of approximately spherical form and rotated slowly on its own axis, the rotation becoming swifter as the mass grew colder and contracted. In time rings of matter would be left behind the main mass (not thrown off, as is sometimes stated); each of these rings would gradually collect into a single globe, and thus the planets would be formed. A planet thus formed continuing to revolve might itself abandon rings in contracting; these rings would form into the satellites. The rings of Saturn were at one time thought to be examples of this process, but we now know that they are composed of swarms of meteorites rather than of continuous substance. Plateau devised an experiment illustrating this formation of rings. He prepared a mixture of alcohol and water of a specific gravity as nearly as possible equal to that of oil. Some oil was then poured into the mixture. As the bottom of the mixture was slightly more dense than the oil, and the top slightly less dense, the oil sank half-way and floated in the middle as a round ball. By means of a disk attached to a wire the ball of oil was set rotating. The effect of the rotation caused the oil globe to expand into the form of a spheroid flattened at the poles, and this flattening increased with the speed, until at last a ring was formed which revolved round the globe. After a time the ring broke up and gathered into a smaller globe which rotated, besides revolving round the large globe.

Laplace supposed that the rings would rotate as though solid, their outer edges thus moving more swiftly than the inner, and thus the planets formed therefrom would rotate in the same direction. The "exceptional cases" of our system—the fact that the satellites of Uranus and Neptune move in the opposite direction to that in which most of the other members do, and the swift revolution of the inner satellite of Mars—cannot be explained by this form of the hypothesis.

M. Faye, however, by modifying the original idea of Laplace, and supposing that the planets were formed by local condensations (not by the detachment of rings) within the revolving nebula, and that the outer planets, Uranus and Neptune, have been more recently formed than the rest, has shown that these bodies would have retrograde rotation on their axes, which he supposed to be the case from the motion of their satellites. Since, however, Saturn's rotation is in the same direction as that of our own earth, and eight of its satellites move in one direction, but the last discovered (Phœbe) moves in the opposite direction, we have still a difficulty, unless we suppose this body to be a recent capture and not an original member of the Saturnian family. The same thing is the case also with the eighth satellite of Jupiter, whose motion is retrograde, while the other seven have direct motion. Prof. Sir George Darwin by his theory of tidal evolution has attempted to explain the swift motion of the inner satellite of Mars, the fact that the moon always turns the same face toward the earth, and that the rotation period of Mercury (and probably that of some of the satellites of Jupiter and Saturn) is the same as that of its revolution. He has given reasons for thinking that in former ages the period of rotation of Mars was much shorter than at present, but that by tidal action of the sun this period has been gradually lengthened to its present value; at the same time the satellite's period is supposed to be shortening, and its distance from the planet slowly diminishing. In the case of the moon, he considers that millions of years ago our earth was rotating much more quickly than at present. In contracting, a portion separated from the rest, and gradually receded, becoming the moon. The earth's tidal action upon the latter has resulted in the periods of rotation and revolution becoming equal to one another. The ancient Arcadians are said to have boasted that their race came into existence before the moon, but they were probably unaware of the period they claimed for their ancestry (fifty-seven millions of years!). The observations of Schiaparelli having led him to the conclusion that the planet Mercury (which is the nearest known planet to the sun) rotates on its axis in a period equal to that of its revolution round the sun (88 days), Sir George Darwin considers this is due in a similar manner to the tidal action of the central body having lengthened the planet's period of rotation until the latter always presents the same hemisphere toward the sun, just as the moon does toward the earth. The same thing has been asserted of the planet Venus also, but it still seems probable that the shorter period of 23½ hours, determined by the early Italian observers, is the true length of the "day" on the earth's "twin sister."

Further modifications, in consequence of increased knowledge of actual existing nebulæ and the applications of the principles of energy and thermodynamics, have been proposed from time to time; and most supporters of the nebular hypothesis no longer believe that in its original condition the "nebula" was even at so high a temperature as that of the sun at present. It is considered probable that the original nebula was largely composed of meteorites, which by collisions during their gradual drawing together would grow hotter and hotter. After a time the central mass would become an intensely hot "white" star. Later on, the loss of heat from radiation exceeding the gain from contraction and condensation, the star would cool down and perhaps finally become a dark body like the companion to Algol. The planets, being smaller than the star or sun round which they revolved, would cool down at a much quicker rate, losing more heat from their surfaces and becoming nonluminous bodies, while their interiors would be still very hot. Our earth and the inner planets seem to have reached this stage, while Jupiter and Saturn appear to be still, to a small extent, self-luminous. Estimates of the past and future duration of our system have been formed by Lord Kelvin, Helmholtz and others; but the very various lengths of time given, ranging from twenty to four hundred millions of years, alone show that these periods are little more than rough guesses, needing further knowledge to be of value. The discovery of the properties of radium has enormously extended the probable future duration of the sun's heat. "We have every reason to think," says Arrhenius, "that the sun's chemical energy will suffice to maintain its heat during thousands of millions, perhaps billions of years."

In 1861 Babinet proposed the application of a criterion, based on the mechanical principle of the "conservation of areas." He showed that if ω be the sun's angular velocity of rotation, with radius r, and ωr represent these quantities when the globe is expanded so as to have the radius r, then

$\omega r^2 = \omega' r'^2$ [Moment of momentum, a constant quantity for a system rotating freely and subject to no external forces]

or

$$C = \Sigma m r^2 \omega = \omega \Sigma m r^2 = \omega \Sigma' m r'^2.$$

Suppose now the "solar nebula" extending to the earth's orbit, let us find its time of rotation. We get for this

$$25.3 \text{ days} \left(\frac{23{,}445}{109.5}\right)^2 = 3{,}192 \text{ years.}$$

For the case of Neptune, whose mean distance is thirty times that of the earth from the sun, the solar nebula when reaching to that distance will rotate in

$$25.3 \text{ days} \left(\frac{30 \times 23{,}445}{109.5}\right)^2 = 2{,}888{,}533 \text{ years.}$$

(These figures are taken from a paper by Dr. See.)

Applying this criterion to the case of the various planets and satellites of our system, we find periods in every case much greater than the known periods of revolution of these bodies. The earth revolves in one year about the sun, Neptune in about a hundred and sixty-five years. Thus it follows that the "hypothetical solar nebula could not have rotated with sufficient speed to detach the masses," when it extended to the orbits of the several planets, as Laplace supposed. The evolution of the planets by separation of rings of matter from the central condensation, through rotational instability, must therefore be abandoned. It is, however, possible that secondary condensation nuclei might be formed by gravitational instability within the gaseous nebula; and this has been pointed out by Mr. Jeans in papers which he has contributed to the Philosophical Transactions of the Royal Society.

We turn now to the alternative hypothesis developed by the work of Prof. T. J. J. See. He has recently pointed out that some remarkable anticipations of his views as to the action of a resisting medium were made by Euler in 1749. The essential features of this hypothesis are that the Solar System has been formed from a spiral nebula, and that the planets have not been detached from the central mass through its rotation but have been captured or added on from the outer parts of the nebula. The roundness of the orbits of the planets and satellites in general use is due to the action of a resisting medium which has reduced the size of their paths, and well nigh obliterated the deviations from circularity. Just as the planets have been captured by the sun's action, so in like manner the satellites have been captured by their several primaries, not detached by rotation of these latter. The moon too was originally a planet, which neared the earth and was finally captured and made a satellite. The asteroids or minor planets between the orbits of Mars and Jupiter are the surviving remains of millions of small planets, most of which have been swallowed up by colliding with larger ones, though many are still moving in independent paths round the sun. Our own earth frequently encounters some of these objects, and we have then a more or less brilliant "meteor shower." The satellites having been captured in this way, it is not surprising that a few of them should revolve in the opposite direction to the rest. It is also remarkable that the paths of Phœbe (Saturn's 9th satellite) and of the 8th satellite of Jupiter are much more oval than those of any other known satellites, from which it would appear that the density of the resisting medium must have been very slight at the great distances from the planets at which they revolve. The planetary rotations have also been produced by the capture and absorption of small bodies; and thus the larger planets Jupiter and Saturn should rotate most rapidly, as is known to be the case.

It has long been known that the effect of a resisting medium on the paths of bodies moving in it, in a manner analogous to the planets moving round the sun is (1) to reduce their distances from the central body; (2) to diminish the eccentricity of their orbits, i. e., to make these more nearly circular.

The proof of this is given in works on analytical dynamics (Cheyne's *Planetary Theory* and other books) and was of course well known to Laplace, who says, "At the same time the planet approaches the sun, by the effect of the resisting medium the orbit also becomes rounder." The well-known comet of Encké is thought to be gradually drawing nearer to the sun by such an action.

Thus the present shape of the planetary paths is accounted for, the action of the resisting medium having changed their orbits. Around each planet circulates a vortex of cosmical dust, and the descent of this material upon the surfaces of sun and planets is considered to give rise to the accelerations of their equatorial regions—i. e., the fact that the parts of the sun, Jupiter and Saturn near their respective equators have a shorter period of rotation than those farther north or south. However, there is no perceptible difference of rotation in different regions of our own earth or of Mars, so far as known and the amount of matter required to produce such an effect (at present) seems greater than can reasonably be supposed to fall upon the surfaces of the planetary bodies.

A similar difficulty occurs in the meteoric theory of the sun's heat, attributing the latter to the impact produced by the fall of countless meteorites upon its surface. No doubt such bodies do fall upon the surface of the sun in considerable quantities, but the amount required to maintain the sun's output of heat is so enormous that there should be an enormously greater quantity in regions near the sun, so that our own earth ought to receive nearly half as much heat as she gets from the sun by impact with meteors. This is certainly not the case.

The descent of matter upon the sun increasing its mass may also account for the small secular acceleration of the earth indicated by the observations of eclipses, and the outstanding motion of the perihelion

of Mercury, which Leverrier attributed to a planet or ring of small planets lying between Mercury and the sun, may be also explained in this manner.

The moon having suffered numerous collisions with smaller satellites has had its surface marked with the round sunken craters which are so distinctive a feature.

So different a theory from the ordinary volcanic one, however, will not be easily accepted by selenologists. Prof. See considers that the almost perfect circularity of Neptune's orbit shows that it cannot be the outermost planet of our system, the roundness indicating that the nebulous medium was quite dense at that distance, and consequently the limits of the system are much farther out. Others planets lying beyond Neptune have been suspected and may yet be discovered by the telescope. It is remarkable that Prof. Forbes considers that one of these bodies, whose distance he supposes is about a hundred times that of the earth from the sun, and consequently would have a period of a thousand years (by Kepler's third law, squares of periodic times as cubes of distances from sun, $1,000^2 = 1,000,000 = 100^3$) moves in a very eccentric orbit, whose plane makes a large angle to that of the ecliptic, the resisting medium at that distance apparently having had little effect on its motion.

The solar system, in the opinion of Prof. See, was formed from a spiral nebula, the latter arising from the meeting of two or more streams of cosmical dust. The system began to whirl about a central point and thus gave rise to a vortex. Great numbers of spiral nebulæ are now known to exist scattered out over the heavens, millions of these objects being visible in the most powerful telescopes. On the other hand, it has been pointed out that there are very few nebulæ of the oblate spheroidal form, such as the hypothesis of Laplace assumed, to be met with in the sky. "Such nebulæ as we see have, it seems, a greater analogy with the solar corona than with the fiery condensing mists conceived of by Laplace" (Proctor, "Old and New Astronomy," § 1445).

The rotation period of Mars being about 24 hours 37 minutes and that of our own earth 23 hours 56 minutes, Prof. See considers that the period 23 hours 21 minutes for Venus, obtained by the early Italian observers, is probably about its true value, and thus the planet is habitable and probably inhabited by intelligent beings.

It is well known that periodic comets probably owe their present position as permanent members of our system to the action of the planets. When a comet coming from outer space in a parabolic orbit approaches a planet its motion is either accelerated or retarded. In the latter case the parabola becomes an ellipse, and the comet henceforth moves in a closed path around the sun, always coming at each revolution to (or near to) the point where this retardation commences. Thus arise the planets' families of comets.

A very large number of members of Jupiter's family of comets are known; Halley's famous comet is a member of Neptune's family. In a similar manner it is supposed that the asteroids and satellites have attained their present positions. The whirling of the gaseous matter of a spiral nebula is considered to be due to the unsymmetrical meeting of two streams or to the settling down of a nebula of unsymmetrical figure. From this ultimately results a star surrounded by a system of planets and satellites. The two opposite branches of spiral nebulæ often seen on photographs represent the "original streams of cosmical dust which are coiling up and forming spiral systems." If the streams so converge that the nebulous mass becomes very concentrated, the nebula may divide at its center and give rise to a double star.

This theory of the capture of the planets and the rounding of their orbits by the action of the resisting medium gives results in some cases the exact opposite to those which are given by the theory of tidal evolution, as investigated by Sir George Darwin.

While tidal friction usually increases the major axis and eccentricity of an orbit, the resisting medium as regularly decreases both elements. "In the actual physical universe both causes are at work together, sometimes one influence preponderating and then the other." With a large central sun and small planets, as in our system, the action of the resisting medium is most effective; for systems made up of two large masses, tidal friction is the predominating agency.

There can be little doubt that these researches form a most important advance in our knowledge of the genesis of our system; and though answers more or less satisfactory may be found to parts of the criticism of Laplace's famous hypothesis, yet we may fairly say that, if not completely disproved, it has been very seriously undermined.

It is not to be supposed, however, that the alternative hypothesis is free from difficulties, some of which have been slightly outlined, but we may still say that it gives a reasonable explanation of many remarkable peculiarities. Further evidence in its favor is no doubt wanted, as well as spectroscopic proofs of motions derived from the study of actual existing spiral nebulæ. Some recent work by Dr. Nolke on the effect of a resisting medium in the evolution of the solar system from a primitive nebulous condition has been published by him at Berlin. Sir George Darwin in his article on "The Genesis of Double Stars" gives an interesting historical account of work on the theory of the equilibrium of revolving liquid bodies, by Poincaré, Jeans, and others, together with an application of their results to stars of the Algol type. Probably there is no subject more fascinating than the question as to the past and future of our system; and though from our limited experience, both in time and space, there is the greatest necessity for caution in drawing conclusions, yet the mind of man seems so constituted that it cannot help doing so. It remains for the future to show whether "the vast masses of observational data accumulated by the persevering industry of self-denying men of science" can be put together in the manner indicated above to yield the laws of stellar evolution.—*Science Progress.*

Cheese as an Article of Diet

A Food That is Much Neglected

While experiments have established the facts as to some debatable questions concerning the comparative digestibility of green and cured cheese, perhaps the most valuable result has been in showing clearly the great value as food of all the more common varieties of cheese.

The Swiss, who are a very healthy people, eat largely of cheese; in fact, bread and cheese form the greater part of the diet of many of them. Many other European races eat largely of cheese. The miners of England consume very much of the poor cheese made in the United States, especially the high-acid cheese, using it extensively for seasoning; and the Germans eat large quantities of the cheap but highly flavored skim-milk cheese such as the hand käse, which has perhaps the most pungent ordor of all the varieties of cheese made.

In the matter of comparative food values it was thought that the results of the experiments given in this report made it safe to assume that cheese was as fully digested as most of the ordinary food materials which have been studied in earlier experiments carried on in connection with the nutrition work of the Department of Agriculture. It would, in fact, be undesirable for a larger per cent of any food material to be absorbed than was the case with the cheese.

Heretofore cheese has seldom been regarded seriously by consumers of any class in the United States as a possible cheap staple food. All consumers of cheese with very few exceptions use it as a luxury in small quantities at comparatively rare intervals. While in the aggregate a large quantity of cheese is eaten in the United States, the quantity is nevertheless almost negligible when compared with some other products of less food value and inferior palatability.

The greater part of the cheese consumed in this country is eaten without any preparation, while in many European countries the cheese is either sprinkled on other foods—vegetables usually—or is cooked with the food. Americans evidently have much to learn from Europeans of some of the possibilities of preparing such dishes. A number of European varieties of cheese are made extensively and exclusively for use in connection with other foods or in cooking. Among these is the well-known Parmesan, a hard cheese made from skimmed milk; and also the sap sago cheese, a small conical-shaped cheese made from skimmed milk and highly seasoned with herbs. The Italians use cheese for flavoring as Americans use salt and pepper, having it grated and constantly at hand in a small shaker. With them macaroni with cheese is a common dish, as are other cheese preparations. An excellent dish is the cheese omelet, while warmed-up potatoes can be made very appetizing when cooked with cheese.

It may be, perhaps, that the American people have gone so far in the consumption of only partly ripened and mild-flavored cheese that the probability of learning to use cheese as a flavoring are very remote, as it is only the well-ripened or highly flavored cheeses that are satisfactory for flavoring purposes. It is perhaps a matter for some regret that so much mild-flavored cheese has come to be used, as it is probable that much more satisfaction would be felt by consumers in general with this great food product if they had learned to like the well-ripened product with a well-developed flavor. It is generally conceded that people who like a highly-flavored cheese never become tired of it.

A comparison of the food value of cheese with that of other highly nitrogenous food materials may be of interesting value. No kind of meat excepting dried beef carries such a large percentage of protein as cheese, and as dried beef contains a much greater percentage of water, the other food constituents aside from the portein are much less than is found in cheese. Fresh beef as purchased has, weight for weight, little more than half the food value of cheese in either protein or fat, and the same is true of practically all other fresh meats, which have in many cases such a large percentage of refuse and in all cases such a large percentage of water that they are noticeably inferior to cheese in food value. Bacon or fat pork are exceptions, but their food value is mostly in the fat, which can be and is replaced to a great extent by the carbohydrates of vegetables at a much less cost and sometimes perhaps at a benefit to the health of the consumer. Fish and pork each have a notably large percentage of refuse, while eggs have a high percentage of water. To sum the matter up, a pound of cheese has nearly the same food value as two pounds of fresh beef or any other fresh meat as food; it is worth as much as or more than a pound of ham and is more digestible, and it is equal to two pounds of eggs or three pounds of fish. In price good cheese made from unskimmed milk costs about a third more than round steak and twice as much as the cheaper boiling beef, while it costs practically the same per pound as smoked ham and bacon. It costs usually a third more than fresh fish.

Cottage cheese or cheese made from partially skimmed milk is cheaper even than the American or Cheddar cheese. The first costs about one-third as much and the partly skimmed product about two-thirds as much as the so-called "full cream" cheese. Practically the only food product that rivals cheese in food value and cheapness is dried beans.

In view of the foregoing comparison of food values it is a matter of some wonder why there is not more of a demand for cheese, especially by people of limited means. Estimates made by the Department of Agriculture, in the twenty-second and twenty-sixth annual reports of this bureau and in Bulletin 55 of the Bureau of Statistics, show that the people of the United States consume between 169 and 185 pounds of meat annually per capita, besides fish and poultry, while the annual consumption of cheese is only about four pounds per capita. Even granted that fresh meats are more palatable to most people, some other explanation must be found for this wide difference in the quantity of the two products eaten. A great proportion of the laboring class in this country are able to eat plenty of wholesome food, but they cannot afford to discriminate against a cheap, palatable, and wholesome food in favor of a higher-priced food. The only way to account for the comparatively limited demand for cheese is on the basis of custom and lack of knowledge. People usually eat what they have been accustomed to, making variations within narrow limits only, and never changing the general character of their food. New foods are not sought.

In this connection particular interest attaches to the quantity of salt or cured pork products eaten in comparison with cheese. Cured pork, ham, and bacon, to about seven times the value of cheese are eaten annually. No one can say that the pork products, with the exception of good ham, are more palatable than cheese, and they are not known to be more healthful. These pork products are usually eaten by the poorer classes who cannot afford to buy fresh meat, but who could afford to buy cheese, and cheese makes a better food in the dietary, because of its high protein content.

Cheese can no longer be discriminated against because of a suspicion that it is not a healthful food. The absolute lack of any disturbance of the general health of the subjects used in the experiments reported in this bulletin is proof that cheese can be eaten in large quantities without danger to health. The Swiss cheesemakers, also many of the Swiss farmers of southern Wisconsin, eat unusually large quantities of cheese, and they are noted for athletic attainments and physical endurance. They brought the custom of eating cheese from their native country, where cheese is a very important item in the diet. The consuming public, especially that part of it which needs to practice economy in buying food, would do well to turn its attention a little more toward cheese, since greater quantities can be used at a saving to the consumer.—Abstract from Circular 166, Bureau of Animal Industry.

The Use of Electricity in the Metallurgy of Iron

A Turning Point in the History of Iron

A turning point in the history of iron occurred in the sixteenth century, when the increasing demand for iron led to the employment of water power to work the bellows of the blast furnace and consequently led to the location of iron works beside waterfalls. The steadily increasing capacity of the bellows, which was made first of leather, afterward of wood, and was not superseded by the iron cylinder pump until 1760, enabled the height of the furnace to be correspondingly increased, the fuel (wood charcoal) to be better utilized and the temperature to be raised sufficiently to produce large quantities of fused pig iron, containing much dissolved carbon, instead of the small lumps of half-fused malleable iron produced by the old low furnace with its bellows laboriously worked with the hand or foot.

The invention of the steam engine made it possible to dispense with water power, so that in the eighteenth century the iron industry began to leave the waterfalls and to seek sites convenient to the coal mines, for the depletion of the forests made it necessary to employ coal or coke, instead of wood charcoal. Now, barely 150 years after this second revolution, the iron industry appears to be returning to the streams, at least in regions abounding in water power, and thus preparing for the day, some 200 years hence, when it will be necessary to economize the rapidly diminishing store of coal, by obtaining from electrical energy produced by water power most of the heat required for the manufacture of iron.

This is the opinion of Dr. Prettner, who gives, in

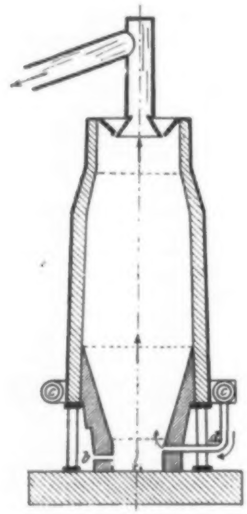


Fig. 1.—COMMON BLAST FURNACE

Prometheus, the following comparison between electric and other iron and steel furnaces:

Iron furnaces heated by coal or gas are of two classes: blast furnaces in which pig iron is produced from the ore, and the various furnaces employed in the transformation of pig iron into malleable iron and steel of different qualities. For the present, the same distinction must be observed in electric iron furnaces, although it appears possible to produce steel directly from iron ore in the electric blast furnace. Hence we will first compare the ordinary blast furnace with its electric rival, and then make a similar comparison of refining and steel furnaces.

The world's annual output of 50 million tons of pig iron is practically all produced in blast furnaces of the general type shown in Fig. 1. The ordinary furnace of this type is 60 or 70 feet high and produces about 100 tons of pig iron per day, but 300 tons are produced daily by each of the two largest German furnaces, operated by the Krupps and the Rhenish Steel Works.

The furnace is filled with alternate layers of coke (sometimes charcoal, especially in Sweden) and of iron ore mixed with a certain proportion of limestone or other slag-forming material. As the mass settles down in consequence of combustion and fusion the furnace is replenished at the top, and the operation continues without interruption for months or years. The very high temperature, estimated at 2,000 deg. C. (3,632 deg. F.), required at the bottom, or hearth, is obtained by a blast of air heated to 500 or 600 deg. C. (about 1,000 deg. F.), which is forced in through pipes called tuyères (*d*, Fig. 1.). The carbon dioxide (CO_2) formed by the combination of the entering air with the glowing coke which it first meets, takes up more carbon from the other layers, and is thus reduced to carbon monoxide (CO). At the bottom of the furnace some of this carbon monoxide meets small grains of very hot but unmelted and very pure iron and is partially reduced to very fine particles of carbon, which unite with the iron to form a fusible com-

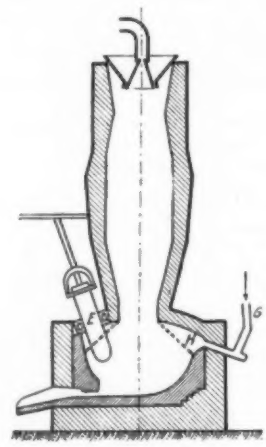


Fig. 2.—SWEDISH ELECTRIC BLAST FURNACE

pound, containing from 3 to 5 per cent of carbon. This compound, known as pig iron, collects in liquid form at the bottom of the furnace, whence it is drawn off, at intervals, by tapping the furnace at the point *a*, and is run into sand molds, forming "pigs." The lighter fused slag is drawn off through an orifice at *b*. Pig iron contains, in addition to carbon, varying quantities of manganese, silicon, phosphorus, and sulphur, which affect the quality of the iron and determine the methods by which it is converted into steel. In the upper part of the furnace another portion of the carbon monoxide reacts with the heated ore (usually an impure oxide of iron), producing carbon dioxide and the pure granular iron already described. The gas which escapes from the top of the furnace contains 60 per cent of nitrogen, 12 per cent of carbon dioxide, 24 per cent of carbon monoxide, and 4 per cent of hydrogen and hydrocarbons. Hence the mixture is combustible. The combustion of one cubic meter of blast furnace gas produces 900 calories, or units of heat. (Standard illuminating gas yields 5,000 calories per cubic meter.) The gas is burned, intermittently, in towers or chimneys about 50 feet high, containing numerous masonry barriers, which store up the heat of combustion and subsequently communicate it to the hot air blast, which is passed through the same towers. Steam boilers are also heated with blast furnace gas.

In its present stage of development, the electric blast furnace appears puny and insignificant in comparison with its veteran adversary. Canada, rich in ore and water power, but poor in coal, presents ideal conditions for the production of iron by electricity. A Canadian commission experimented with Keller's electric furnace in 1904, and with Héroult's furnace in 1906. The experiments proved that all varieties of iron ore could be reduced by electricity, that either gray or white pig iron containing only 1/100 per cent of sulphur could be produced at will, by regulating the quantity of coke, and that charcoal of inferior

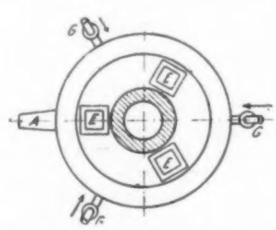


Fig. 3.—PLAN OF SWEDISH ELECTRIC BLAST FURNACE

quality could be employed. (Gray pig iron presents a gray surface of fracture, with distinct crystals of carbon in the form of graphite, and contains a large proportion of silicon. White pig iron presents a white fracture, without visible particles of carbon, and contains a large proportion of manganese.)

The electric furnaces used in these experiments were of small height, open at the top, and built of fire-resisting stone. The electrodes were blocks of solid or compressed carbon, one of which formed the bottom of the furnace, while the other was suspended in the upper part.

Three Swedish engineers, Grönwall, Lindblat and Stalhane, independently of their French predecessors, subsequently developed the first practical electric blast furnace in Sweden, where the conditions are similar to those found in Canada. This furnace was in continuous operation during three months, in 1909, until it was stopped by a general strike. The results were so encouraging that a 2,500-horse-power furnace, capable of producing 7,500 tons of pig iron per year, has recently been built, and the erection of others is contemplated. An ordinary blast furnace produces nearly five times this quantity, but the electrometallurgy of iron is still in its infancy.

The Swedish electric blast furnace (Fig. 2) bears a general resemblance to the ordinary blast furnace. It consists of a wide hearth, 8 feet high, surmounted by a narrower shaft, 16½ feet high. The various chemical processes, which are distributed throughout the height of the common blast furnace, here take place almost entirely in the hearth, which is lined with fire-resisting magnesite and is arched above, so that an annular space (*H*, Fig. 2) is left vacant above the cone of ore and coke which has descended from the shaft. This space is essential to the durability of the furnace, and its effect is increased by blowing in cooled furnace gas through the pipe *G*. In the preliminary experiments the wall of the furnace was soon punctured at this point by its contact with the electrode and the hot contents of the furnace. There are three electrodes of carbon, about 5 feet long (*E*, Figs. 2 and 3), which penetrate the hot mass to a depth that can be regulated, and are connected with a three-phase system of 25 periods and about 40 volts. The currents traverse the poorly conducting mixture of

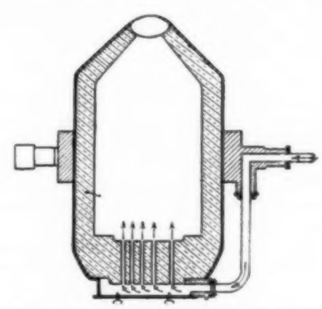


Fig. 4.—BESSEMER CONVERTER

ore, coke, etc., and heat it so strong that the quantity of coke used need be only enough to deoxidize the ore and furnish the carbon of the fusible pig iron. Thus the large quantity of fuel required to maintain the high temperature of the reaction and to melt the iron and slag in the common blast furnace is here replaced by electric energy. As no air is admitted, the furnace gas contains no nitrogen. It consists of 40 per cent of carbon dioxide, 48 per cent of carbon monoxide, and 12 per cent of hydrogen, and it produces, in combustion, 1,750 calories per cubic meter, nearly twice the heat produced by ordinary blast furnace gas. This gas is cooled and blown into the furnace to cool the electrodes, thus accomplishing a closed cycle. It appears probable that by still further diminishing the quantity of coke and by other modifications a sort of crude steel can be produced in the electric blast furnace.

The heat produced by 1 kilogramme (2.2 pounds) of good fuel can be furnished, according to Stassano, by 3, and, according to Lowthian Bell, by 4 horse-power hours of electric energy. Hence in districts where 1 kilogramme of good coal costs more than 3 or 4 electric horse-power hours, the electric blast furnace can be used with advantage. This is the case in Sweden. In the German iron producing districts, in Silesia, Westphalia, and along the Rhine, iron ore and coal are found so near each other, and coal is still so abundant and cheap, that electricity is not yet needed for the reduction of iron ore, but even here the electric steel furnace has begun to claim attention.

In order to describe intelligibly the considerable progress that has been made in the development of the electric steel furnace, we must first review briefly the current methods of producing steel and malleable iron. The pig iron produced in the blast furnace is available for a few uses, as cast iron, but its impurities make it too brittle for most purposes. It contains, according to the character of the ore and that of the ultimate product of which it is designed to serve as the raw material, the following percentages of impurities: carbon 3 to 5, silicon 1/5 to 3, man-

ganese 1/10 to 6 or more, sulphur to 1/2, and phosphorus to 3. Wrought iron contains from 1/20 to 1/2 per cent, steel from 1/2 to 1.8 per cent of carbon, and neither should contain more than 1 per cent of silicon or manganese, or more than 3/100 per cent of phosphorus or sulphur. The function of refining and steel furnaces is to reduce the impurities of pig iron to these permissible limits.

The classical types of modern steel furnace are the Bessemer and the Siemens-Martin.

The Bessemer converter, invented in 1855 (Fig. 4), differs from all other refining furnaces by being hung on trunnions, so that it can be emptied by tipping, and also by employing no fuel except the superfluous carbon of the pig iron, which is poured into it in the fused state at a temperature of about 1,300 deg. C. (about 2,400 deg. F.). The converter is made of iron and is lined with quartzite. The charge having been introduced, compressed air is forced through a pipe which passes through the outer part of one trunnion and terminates in a chamber at the bottom of the converter, whence the compressed air flows through a number of passages in the bottom lining and bubbles upward through the molten pig iron, burning out most of the impurities, particularly carbon, silicon and manganese. The heat produced by this internal combustion is sufficient to raise the temperature of the mass above 1,800 deg. C. (about 3,300 deg. F.) and to cause violent ebullition or "spitting," if the process is not carefully regulated. By this operation the pig iron is converted into very pure malleable iron containing a small proportion of carbon. In order to produce steel a quantity of carbon, usually in the form of "spiegeleisen," a variety of cast iron which contains a large proportion of carbon, is added toward the end of the process. The entire operation, including this "recarbonizing" phase, is accomplished in 20 or 25 minutes, and yields from 10 to 15 tons of steel, according to the size of the converter.

In the Bessemer process the phosphorus of the pig iron is oxidized to phosphoric acid which cannot combine with the quartzite, or silica, with which the converter is lined. Thomas substituted a lining of lime and magnesia, which absorbs the phosphoric acid, and permits the employment of pig iron containing a large percentage of phosphorus. The used linings form a by-product known as "Thomas slag," which contains a large proportion of phosphoric acid and is sold as an agricultural fertilizer for a sum which covers a large part of the cost of the operation. The introduction of the Thomas-Bessemer process in 1878 has given great value to extensive German deposits of iron ore containing so much phosphorus that it was formerly almost worthless, and has saved millions of dollars which otherwise would have been expended for imported phosphates.

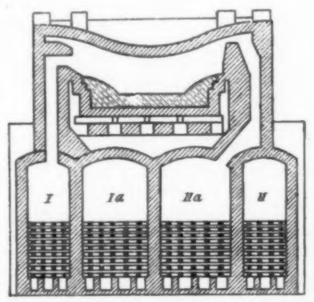


Fig. 5.—SIEMENS-MARTIN FURNACE

At present the Bessemer converter is employed less extensively than the Siemens-Martin furnace, which saves the great cost of compressed air, and also affords a means of utilizing the constantly increasing accumulations of scrap steel and wrought iron. This scrap, melted with varying proportions of pig iron in the Siemens-Martin furnace, yields Siemens-Martin steel or malleable iron. The furnace is of the open hearth type, the iron being melted by a gas flame applied to its upper surface. The gas is produced by the imperfect combustion of coal in special generators, and is rich in carbon monoxide and hydrocarbons. The Siemens-Martin furnace (Fig. 5) consists of the Martin furnace proper and four Siemens "regenerators" placed beneath it. These regenerators are partly filled with masses of fire brick. The coal gas and the air required for its combustion are first admitted to the furnace through the left-hand chambers *I* and *Ia* (Fig. 5), the larger chamber *Ia* forming the air channel, while the hot product of combustion, or furnace gas, escapes through the right-hand chambers, *II* and *IIa*. After a time the flow is reversed, so that the coal gas and air enter through the right-hand chambers which have been heated by the hot furnace gas, while the freshly formed furnace gas escapes through the left-hand chambers. By thus reversing the flow at intervals determined by experience the

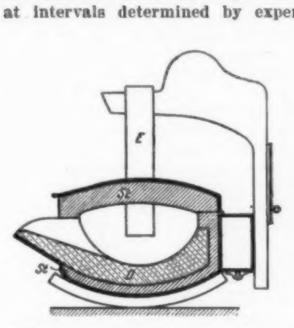


Fig. 6.—HÉROULT'S ELECTRIC ARC FURNACE

hot furnace gas is caused to give up indirectly to the coal gas and air a quantity of heat which, added to the heat of combustion, produces the very high temperature of 3,300 deg. F., which is required to melt wrought iron. Recarbonizing is practised in the Siemens-Martin process and various additions are made at different stages, while the process is carefully watched and controlled by testing samples of the product. The ordinary Siemens-Martin furnace produces 10 to 15 tons in 5 to 8 hours.

The finest grades of steel, used for instruments of precision, etc., have hitherto been produced in crucibles of 50 to 150 pounds capacity, combined in large numbers in elaborate and costly furnaces, which are also better adapted than the Siemens-Martin furnace to the production of the nickel-steel, chrome-steel, and tungsten-steel of which screw-propellers and armor plates are made.

Now, all of these crucible steels, and still finer grades, can be produced with advantage in the electric steel furnace, the first cost of which is less than that of the crucible furnace, and which can usually be operated cheaply by gas engines fed with blast furnace gas. The electric process, also, is more flexible than any other. A portion of the product can be drawn off at any stage and the remainder can be converted into steel containing less or more carbon, or into nickel-steel, etc. The electric furnace may also be allowed to "freeze," or become cold, as the metal is not exposed to the air but is protected by a layer of slag, so that it can be remelted at any time by turning on the current. If a filled Bessemer converter "freezes" it must be taken apart. In the Siemens-Martin furnace a frozen charge can be remelted, but not without losing much iron in the form of slag. Electro-steel is superior to crucible steel in its absolute freedom from bubbles and sulphur and phosphorus streaks, as well as in its forging qualities. It also can be made from inferior raw material.

In the direct electric process the material is both fused and refined in the electric furnace. In the indirect process, which consumes less current, the crude fused product of a Siemens-Martin furnace, for example, is run into the electric furnace and the substances required to effect the desired change in composition are added. The choice between the two methods is governed mainly by the relative cost of coal and of electric energy.

Electric steel furnaces are of three types: Arc (Héroult, Stassano, etc.), resistance (Girod), and induction (Kjellin). Héroult's arc furnace (Fig. 6) appears to be the best of its class. It is a vessel of heavy sheet iron, thickly lined with fire brick (*St*), provided with a movable cover, and so mounted that it can be emptied by tipping. The bottom has an inner lining of calcined magnesian limestone *D*, the function of which is to absorb the oxides of sulphur, phosphorus and silicon. Two carbon electrodes (one of which is shown at *E* in Fig. 6) extend downward through the cover to within two inches of the surface of the fused metal. The electrodes are moved as required, by electric motors and are supplied with alternating current at 100 volts. The heat required for fusion and refining is produced by the electric arc formed between these electrodes. In the indirect process from two to five tons of crude fused steel, according to the size of the furnace, are run in from a tipping Siemens-Martin furnace, of the Wellmann type, and are covered with iron ore. The combined oxygen of the ore supplies the place of the free and too active atmospheric oxygen employed in ordinary steel-making processes, which oxidizes some of the iron and thus causes both loss and impurity. The combined oxygen of the ore oxidizes only the sulphur, phosphorus and silicon to their respective acids, which are partly absorbed by the lime and magnesia below. After 30 minutes the fused slag derived from the ore is drawn off and the surface of the fused metal is immediately covered with a calculated quantity of carbon. This is covered in turn with lime, which absorbs the remainder of the oxides of sulphur, phosphorus and silicon. A little manganese ore is mixed with the lime, and the other required ingredients are added subsequently.

Kjellin's induction furnace (Fig. 7) is employed by the Krupps and several other German steel makers. The fused metal occupies an annular trough surrounding a vertical bar electro magnet, or transformer. The primary coil of the transformer is fed with alternating current at 220 volts, and the secondary coil delivers alternating current at 8 volts. The secondary current is conducted through the metal in the annular trough where it produces sufficient heat to maintain the temperature of fusion. In the direct process the trough is filled with solid pieces of crude steel, cast iron, etc., which make such imperfect contact with each other that it is difficult to establish the current. The difficulty is overcome by laying a steel ring in the trough or by leaving in it a small part of the preced-

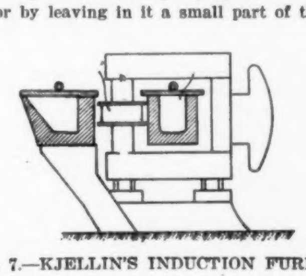


Fig. 7.—KJELLIN'S INDUCTION FURNACE

ing charge. The subsequent operations are similar to those of the Héroult furnace.

The electric steel furnaces now in use are of small capacity. Larger furnaces would consume much less electric energy per ton of steel produced.

No Well-grounded Complaint Against the Farmer

After presenting many details with regard to the increase of prices on farm products between farmer and consumer, the Secretary of Agriculture declares that "the conclusion is inevitable that the consumer has no well-grounded complaint against the farmer for the prices that he pays. The farmer supplies the capital for production and takes the risk of his losses; his crops are at the mercy of drought, and flood, and heat, and frost, to say nothing of noxious insects and blighting diseases. He supplies hard, exacting, unremitting labor. A degree and range of information and intelligence are demanded by agriculture which are hardly equaled in any other occupation. Then there is the risk of overproduction and disastrously low prices. From beginning to end the farmer must steer dextrously to escape perils to his profits, and indeed to his capital, on every hand. At last the products are started on their way to the consumer. The railroad, generally speaking, adds a percentage of increase to the farmer's prices that is not large. After delivery by the railroad the products are stored a short time, are measured into the various retail quantities, more or less small, and the dealers are rid of them as soon as possible. The dealers have risks that are practically small, except credit sales, and such risks as grow out of their trying to do an amount of business which is small as compared with their number."

In continuation of this subject, the Secretary of Agriculture suggests that the problem of high prices is one for treatment by the consumer. "Why do not consumers buy directly from the farmers?" he asks. "A distribution of farm products in this simple way has already begun in England where co-operative organizations of farmers are selling by direct consignment to co-operative organizations of consumers in cities. Farmers' co-operative selling associations are numerous in this country, but co-operative buying associations among the people of cities and towns are few. Aside from buying associations maintained by farmers, hardly any exist in this country. It is apparent, therefore, that the consumer has much to do to work out his own salvation with regard to the prices that he pays. Potatoes were selling last spring in some places where there had been overproduction for 20 cents and in some places for even 9 cents per bushel at the farm, while at the same time city consumers in the East were paying 50 to 75 cents per bushel, although there was nothing to prevent them from combining to buy a carload or more of potatoes directly from the grower and for direct delivery."

Many new forage crops from all parts of the world are being tested every year. Only a few of these possess sufficient value to compete with the crops now grown. Four such plants, however, recently introduced, have given such admirable results that there can be little question that they will prove of great value. Experience of the last three years has shown that Rhodes grass is especially adapted to the Gulf coast region. In southern Florida three cuttings have been made during the winter months and as many as six during the entire season. This grass has fine upright stems and good seed habits and should be extensively cultivated in this region.

Airship and Aeroplane in War*

The Relative Merits of the Dirigible Balloon and the Aeroplane

By Lieut. Frank P. Lahm, U. S. A.

With both the dirigible balloon and aeroplane now in actual use in European armies, it is not too early to compare the two types of air craft, and draw conclusions as to which should be given the preference in equipping our own forces, for equip them we surely must and will, and that before long.

First, let us look into the different rôles to which air machines may be adapted in war. In general, I would limit them to three: First, and by far the most important, is reconnaissance, both strategical and tactical; second, communication, particularly on the field of battle; third and last, combat. I will first take up the third rôle as it need occupy but little of our attention.

The idea of dealing death and destruction in the form of fire and explosives dropped from the air, of annihilating battleships, armies and cities, has from the first appealed to the popular mind. But let not the imagination run riot, for experiments show that, to produce its full effect, the explosive must be confined. A bomb dropped on the deck of a battleship would do little or no harm except to those of the personnel who chanced to be exposing themselves, and no projectile can be given sufficient impetus from an aircraft to penetrate steel and iron. Furthermore, experiments have shown that the chances of hitting the mark from an airship in flight are quite remote, unless the craft approaches within a distance at which it would itself be exposed to extreme danger from the enemy's fire.

The effect of dropping explosives on an army would be more moral than physical, for here again arises the difficulty of hitting the mark, and moreover, even if it were struck, the effect would be limited to a small area and a few men.

Dropped on a city, explosives and inflammables would have an appreciable effect, but stop and estimate the number of bombs and the number of aircraft required to carry them, in destroying a city the size of one or our large seaports such as New York, Boston or San Francisco.

Communication on the field of battle these days of large armies and extended areas of combat has opened a large field of usefulness to aircraft. Wireless and wire lines can now be utilized in connecting the different headquarters and subdivisions of an army on the field of battle, but there must always be an element of unreliability and uncertainty in this method of communication. It takes time to run wire lines, the headquarters to be connected are constantly changing their positions, are often many miles apart and only a limited amount of wire can be carried. 'Interference' limits the number of wireless stations so but one station can send messages at a time. Then there comes times when telegraphic communication is not sufficient. A map or sketch must be transmitted, an insurpassable obstacle intervenes between two parts of the line, the commanding general wishes to visit in person some point of the line or to call a conference of his division commanders. What better means than air machines which know no obstacle and travel in an air line, that is, by the shortest and quickest route?

Reconnaissance is where aircraft will find their real sphere of usefulness. For this they are pre-eminently fitted, and here we may expect to see those changes in strategy and tactics due to the appearance on the horizon of a new and powerful arm.

Let us now look into the special qualifications and limitations of the different types of aircraft. Then we can better draw a comparison between the dirigible and aeroplane, and assign each to its proper sphere.

The practical dirigible preceded the practical aeroplane by seven or eight years and gained a lead the latter has had to contend against ever since. The first military dirigible, the French Lebaudy No. 1, which appeared in 1902, was a comparatively small machine with a capacity of 90,000 cubic feet, one forty horse-power motor and a speed of a little over twenty miles an hour in still air. It was found that this was not sufficient to contend with the ordinary wind, so the dirigible has gone on increasing in size, horse-power and speed until we now see monsters of the Lebaudy type, such as the new 'Morning Post,' owned by the British government. It has a capacity of over 350,000 cubic feet and is capable of making a speed of over thirty-five miles an hour. Other examples of aerial Dreadnoughts are the 'Clément-Bayard II,' with a capacity of 250,000 cubic feet, engines of 260 horse-power and a speed of thirty-five miles; the Wellman transatlantic type which required 345,000 cubic feet of hydrogen to fill it; the Zeppelin rigid type of 150,000 cubic feet capacity.

Among the advantages to be attributed to the dirigible are its weight-carrying capacity and its adaptability for long cross-country flights. Hydrogen gives the lifting power and 1,000 cubic of this very light gas will lift 70 pounds. The Zeppelin airships lift as much as 16 tons, and Wellman's dirigible, with which he tried to cross the Atlantic Ocean, had an ascensional force of over 12 tons. The former has carried as many as forty passengers at a time and the latter, besides its crew of six men, was loaded with fuel and provisions sufficient to last ten days, the maximum length of time they expected to be in the air.

On the other hand, the dirigible has serious limitations which must be taken into account. It cannot operate in a high wind, for like a ship at sea, it must have headway to steer and maintain its course. Winds as a rule are not steady, especially those nearest the earth's surface. A balloon capable of making thirty-five miles an hour in still air would be helpless in a thirty-mile wind, for gusts exceeding thirty miles would be frequent, and five miles an hour is not sufficient headway to maintain a course into or perpendicular to a thirty-mile wind. Here, however, arises an advantage peculiar to the dirigible. It is not dependent on its motors for its buoyancy, and even were the speed of the wind greater than its own speed, it would simply have to ride out the storm, then proceed to its port, and if the wind were blowing in the direction it desired to go, it would proceed under the double power of the wind and its motors, or should the latter break down it would be carried by the wind like a free balloon.

The most serious disadvantage of the dirigible lies in its large size, entailing great cost and numerous personnel, a large gas supply, and, above all, difficulty in maneuvering on the ground at the start and in landing. The dirigible must operate from a fixed port where it can have a house to protect it at night or during a heavy blow, and equally important, a supply of hydrogen gas which must be constantly added to maintain the form of the balloon and preserve its buoyancy. Nearly all the serious accidents to dirigible balloons have occurred owing to difficulty in maneuvering on the ground. A dirigible may be compared to a large sail, in some cases over 300 feet long. When the wind strikes it, human power is not sufficient, so when the airship lands it must be promptly sheltered in a suitable house. Various expedients have been resorted to for the purpose of anchoring a dirigible in the open and keeping its head into the wind, but at best it will always be a decidedly hazardous undertaking. In November, 1907, the French dirigible 'La Patrie' was caught away from its house, broke loose in a storm and in spite of the two hundred soldiers holding it, and after drifting across France, England, Ireland and Scotland floated out over the North Sea and disappeared. In August, 1908, the 'Zeppelin IV,' while flying from Cologne to Lake Constance, was forced to make a landing near Stuttgart, Germany. A storm struck it shortly after, tore it loose from its moorings, carried it into the air; an explosion followed, the airship fell to the ground and was reduced to a mass of tangled wreckage. When the 'Morning Post' made its memorable trip, November 26th, from Paris across the English Channel to the military headquarters at Aldershot, a distance of about 210 miles, in five and one-half hours, the aeronautical soldiers were not able to hold it on landing and it drifted away. A second attempt was successful, but on towing it into the balloon house, the envelope was torn and the gas escaped.

The life of the dirigible is its gas supply. Every day this must be replenished as an unavoidable leakage is constantly going on and air is constantly filtering into the gas, reducing its buoyancy and eventually necessitating a complete new supply. Gas is generally provided in steel tubes loaded with hydrogen under high pressure at the gas factory and shipped into the field. A 100-pound tube will carry 200 cubic feet of gas from which we can estimate for a 350,000 cubic foot balloon; 1,750 of these tubes weighing 175,000 pounds. This would be sufficient to fill it once. For each day it is inflated, an additional three or four thousand cubic feet will be required to replace the gas lost.

Experiments have been made in firing at captive balloons anchored to the ground at fixed points, and it was found that shrapnel fired at mid or even long ranges, could bring them down. No firing has been conducted at dirigible balloons in flight. We know that it offers a large target and that a hole in the envelope allowing the gas to escape will bring it down, but what are the chances of hitting this target? In reconnaissance it is necessary to operate at as low an elevation as three-quarters of a mile, which would be easy range for a high angled balloon gun, but when we remember the target is moving at a speed of at least twenty miles an hour and can constantly vary its altitude, the difficulty of hitting it is very apparent.

The aeroplane, small, compact, of comparatively light weight, speedy, easily handled both on the ground and in the air, has all these advantages to adapt it to military purposes. It is hardly safe to quote figures or records, so rapidly are they surpassed—the wonder of yesterday becomes the commonplace of to-day and the marvels of to-day will be commonplace to-morrow. Already the aeroplane has far exceeded a speed of mile a minute, has risen to a height of more than 11,000 feet, has flown continuously without landing for over eight hours, has carried six persons and has demonstrated its ability as a cross-country craft. These are the performances of to-day; by to-morrow they may appear insignificant. No other product of man's inventive genius has made such rapid strides in its early development. It is now just five years (December, 1905), since Wilbur and Orville Wright made the first human flight in a heavier-than-air machine. Now there are three hundred licensed aeroplane pilots in France alone and successful machines of different types too numerous to mention.

Perhaps the aeroplane's greatest advantage lies in its speed, for speed is the weapon with which aircraft combat their greatest enemy—the wind. With its great speed, it gains in manageability and invulnerability. On October 27th, at Belmont Park, Long Island, we had the remarkable spectacle of aeroplanes 'flying backwards.' On that day Johnstone and Hoxey while operating in a sixty-mile wind, were carried away—one of them more than fifty miles. Both landed safely and returned the next day when the wind had subsided. A year ago few pilots were willing to risk their machines in a twenty-mile wind—now no first-class pilot with a good machine hesitates to fly in a wind of twenty, thirty, forty or more miles an hour. One of the next improvements we may look for in the aeroplane, is automatic control, which will largely eliminate the personal equation and skill of the pilot, and make it manageable, even under the most unfavorable conditions.

The vulnerability of the aeroplane need hardly be considered. Though no experiments have been made, and we have no data, a consideration of the premises is sufficient to convince us that a small target like the aeroplane, flying at a height of three-quarters of a mile or more, at an unknown speed of ten to one hundred miles an hour, depending on whether it is traveling with or against the wind, constantly changing its elevation and direction, is a most difficult target to hit.

The high speed of the aeroplanes has been cited as one of its disadvantages. Some critics maintain it is impossible to observe accurately from an aeroplane moving at forty miles an hour. They lose sight of the fact that at such altitudes a particular position is in sight long before it is reached and long after it is passed. The aeroplane already has a 'slow' record of less than twenty-three miles an hour. By throttling down the engine and passing over a given point, headed into the wind, the aeroplane can carry a skilled observer at such a rate of speed that he will have no difficulty whatever in carrying out his observations.

The aeroplane has carried as many as six persons and can be built to carry more, but we shall never see it used as a means of transportation for large numbers or large weights, for in aeroplane construction, increasing the area by the square, increases the weight by the cube, that is, to double the size of the machine, it is necessary to triple the weight.

Now, to compare the dirigible and aeroplane and draw conclusions as to their relative merits in warfare.

From the point of view of manageability, both on the ground and in the air, the advantage is entirely with the aeroplane. The day that Hoxey and Johnstone controlled their machines in a wind of more than sixty miles an hour, brought them safely to earth and later returned to Belmont Park under their own power, no dirigible balloon would have dared to leave its cover, or had it been caught unawares in such a wind, it would have had to choose between an attempt to cross the Atlantic Ocean or landing with a certainty of being seriously damaged and probably wrecked.

A military dirigible carries a crew of about six men and on the ground requires *an entire company* to handle it. The personnel for an aeroplane is one officer and ten men, which is sufficient to render it entirely independent. The crew comprises an observer and two operators taken from the above personnel.

The cost, while a question of minor importance in time of war, is not to be compared in the two types of machines. The current price for a military aeroplane is $5,000 to $8,000. The price for a dirigible is more than a hundred thousand dollars. The amount paid for a 'Clément-Bayard II.' or a 'Morning Post,' or a Zeppelin would pay for fifty aeroplanes. The upkeep of an aeroplane consists largely in oil and gasoline for the engine, wood and cloth for repairs and the expense of maintaining one officer and ten men. For the dirigible, in adition to the same items for fuel, we must take into account the expense of maintaining an entire company, and most important of all, the gas supply. Hydrogen gas as manufactured at present, costs from $7.00 to $10.00 a thousand cubic feet, simply for materials and power alone, without taking into account the expense of the plant and its operation, nor shipping the gas to the point where it is to be used.

In manageability, both in the air and on the ground, in cost, in vulnerability, in speed, we must accord the aeroplane the advantage. In weight carrying, in long distance communication and in adaptability for wireless communication, the advantage goes to the dirigible. From these relative advantages we can now assign each to its proper sphere.

In the first place the dirigible must have permanent points of attachment, or bases from which it must operate, and to which it must return at short intervals for its gas supply, and especially for protection from the elements. This condition leads us to eliminate it from field armies. Permanent stations along the coast at various points along the main lines of communication inland should be established and equipped with dirigible balloons. Here they can operate from mixed sources of supply and, during invasion, would fulfill their rôles of strategical reconnaissance and long distance communication.

But more important, let us first equip our field armies with aeroplanes, for it is on them we must depend for the last strategical reconnaissance, then for reconnaissance and communication on the field of battle and afterward for keeping in touch with the pursuing, or we hope, the retreating foe.

A group of aeroplanes should be attached to the headquarters of the army in the field. Each will re-

* Abstract of an article in the *Journal of the Military Service Institution.*

quire a personnel of one officer as observer, two skilled pilots, who will be non-commissioned officers, and eight other enlisted men capable of assembling, repairing and dismounting the machine. A housing of canvas is all that will be required, something that can be readily erected and taken down and can be carried on an escort wagon.

On the field of battle, the commanding general will use aeroplanes to personally inspect any part of his command, to reconnoiter any position on his front or flanks, or through a combined reconnaissance of his entire group of aeroplanes, can receive frequent detailed and accurate reports from all the subdivisions of his command, can know the enemy's dispositions and movements both at the front and on the flanks. No longer need his movements be timid or hesitating. He knows where the enemy is concentrated. He knows where he is weakest—a rapidly transmitted order to each of his subdivisions enables him to concentrate at the most favorable point and to take full advantage of his adversary's weakness.

Each subdivision commander will depend on his aeroplane scouts to protect himself from surprise and to report to army headquarters the latest developments in his front.

Other first-class powers are not neglecting this new factor in warfare. We do not know who our next opponent will be, but if it is a first-class power, we shall surely find it with a trained and equipped aeronautical auxiliary. Let us have a sufficient number of aeroplanes, of skilled operators, of trained observers, so that we can take the field on an equal or better footing, for aircraft must be opposed by aircraft, and the advantage to be gained by the use of these machines will go to the side which has the largest number and the speediest, and which makes the boldest and most skillful use of them.

A Convenient and Inexpensive Furnace for Very High Temperatures

By D. F. Calhane, Ph.D.

In an article by Pip in the August 15th, 1910, number of the *Zeitschrift fur Elektrochemie* is described a small furnace for high temperature work.

It occurred to me that a description of a furnace that I have used for the past two years in my laboratory might be of interest.

Some two years ago, in connection with work on nickel alloys, I had occasion to employ high temperatures, over 1,500 deg. C. (2,732 deg. F.). It was especially desired to obtain the melts without carbon contamination. In the furtherance of this work, the following simple and efficient furnace was devised:

Referring to the figure:

A shows the end of two fire-bricks. Four of these were employed to form the outside of the furnace. The two end bricks were cut down to give the proper width to the body of the furnace.

C represents the cross-section of a small fire-clay muffle, such as is sold by the Buffalo Dental Company in connection with its No. 40 Fletcher's crucible furnace. This sits inside the inclosure formed by the fire brick and the extra space is filled with a heat-insulating composition composed of Portland cement, magnesium oxide and powdered asbestos. This is shown by *B* in the figure.

At the bottom of the muffle is placed an alundum block *D*. On this rests a No. O graphite crucible, shown by *G* in the figure.

In this graphite crucible is cast an alundum lining, which keeps the melts from carbon contamination.

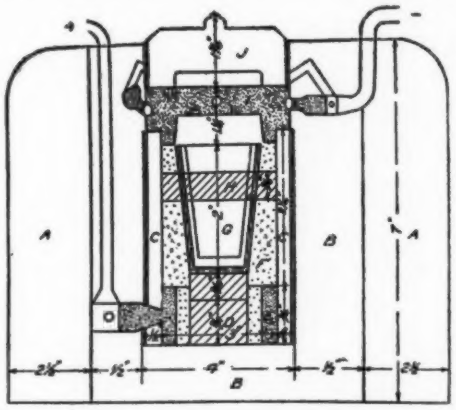


DIAGRAM OF VERY HIGH TEMPERATURE FURNACE

A. Fire Brick.
B. Portland Cement, Magnesia Oxide and Asbestos.
C. Fire Clay Muffle Iron Band.
D. Two Alundum Blocks.
E. Carbon Ring.
F. Powdered Carbon.
G. Alundum Lined Graphite Crucible.
H. Alundum Insulating Ring.
I. Graphite Ring.
J. Fire Clay Cover.

The current enters by the lead at the bottom of the furnace, and is evenly distributed by a graphite ring *E*, that fits flush at the bottom of the muffle. This ring was cut from an odd end of a graphite electrode. The graphite electrodes lend themselves to this kind of work, as they are easily machined, whereas carbon is not.

The carbon resistor is denoted by *F*. This is composed of carbon powder obtained from the National Carbon Company. *H* is an alundum ring, that is dough-nut-shaped. The inner hole is filled to within about one-quarter inch around by the crucible.

This design gives a simple method of insulating the main portion of the resistor, and directs the current flow along the walls of the crucible up through the ring between the walls of crucible and inner edge of the ring. Herein lies the high efficiency of the furnace. Intense heat is concentrated where it is wanted, namely on the walls of the crucible. By varying the area of the space between the crucible and the inner side of the ring, and the height of the block *D*, the voltage and wattage of the furnace can be varied widely.

On the top of the muffle sets a graphite ring *I*, also made from an electrode end. This ring has contacts screwed in as shown, connected with the leads for the exit of the current.

On the upper edge of the ring sits the cover of the muffle *J*. The top, from the upper surface of the fire bricks over to the edge of the cover *J*, is built up with the same insulating mixture used at *B*, and is fashioned to give a symmetrical outline to the furnace. The whole outside may be painted with a water white to give a neat appearance. The whole body of the furnace rests on a cement base that is contained in a shallow, oblong box. The furnace can be thus carried about, as the whole thing weighs only about 25 pounds.

A couple of examples showing the efficiency of the device may be of interest:

In one case the heat-resistivity of the device was pushed to the limit. For this size of furnace 1,330 watts were found to produce a temperature that fused alundum and must have been over 2,500 deg. C. (4,532 deg. F.). In this experiment the furnace absorbed 70 amperes at 19 volts.

In another instance the furnace was calibrated with a platinum-iridium thermocouple and galvanometer up to the limits of this apparatus, namely 1,660 deg. C. (2,912 deg. F.).

The results showed that at 700 watts a temperature of 1,660 deg. C. (2,912 deg. F.) was recorded by the pyrometer. A rough extrapolation on this basis to 1,330 watts would indicate a temperature in the neighborhood of 2,800 deg. C. (5,072 deg. F.).

It might be asked how such a temperature could be attained without melting down the alundum completely. The answer is that the intense heat zone is only along the walls of the crucible where no alundum is directly in contact.

A furnace on the above lines of 6 kilowatts capacity will soon be in use.

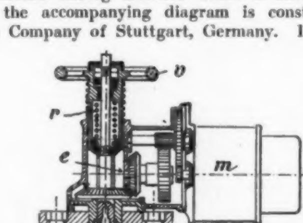
The cost of the size of furnace herewith described is very little. The graphite portions can be turned out on the lathe from electrode odds and ends by anyone who can operate a lathe. The muffle costs about $1.00. The alundum portions, that is the block, crucible lining and ring, were made by the Norton Company. The whole affair should not cost over $4.00 at the most.

Sixty to seventy grammes of metal may be melted in the 1-kilowatt size.

* *Metallurgical and Chemical Engineering.*

Portable Electric Boring Machine with Magnetic Adhesion

The electric boring machine which is shown in section in the accompanying diagram is constructed by the Fein Company of Stuttgart, Germany. It is driven

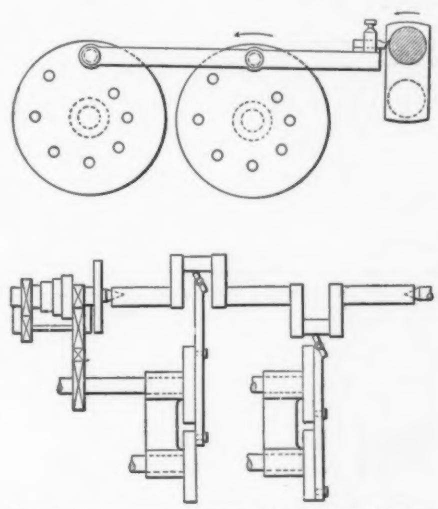


PORTABLE ELECTRIC BORING MACHINE WITH MAGNETIC ADHESION.

by a small electric motor *m*, by means of the bevel gear *e*. The boring tool is advanced, as the work progresses, by the pressure of the spiral spring *r*, the tension of which can be regulated by the wheel *v*. At the same time the machine is pressed forcibly against the plate by the attraction between the latter and the poles of the electromagnet e_1 e_2, which closely embrace the boring tool. (This action occurs only with plates of iron or steel, for which the machine is designed.) The machine is easily operated in any position. It is only necessary to suspend it from a convenient support, to apply the tool to the place to be bored and to close, first the circuit of the electromagnet, and then that of the motor. The work of attendant is confined to watching the operation and turning the tension wheel *v*, from time to time, as the work advances.—*Le Génie Civil.*

Crank Turning Device

Patents have been applied for in Great Britain for the device working on the principle shown in the line engraving herewith, intended for turning crank pins, and pieces rotating around a central shaft in a similar manner. In the upper part of the figure, the general principle of the device is indicated, the lower part being a plan view showing diagrammatically its connection with the lathe to which it is applied. The principle of the device is easily seen from the illustration. The crank shaft is mounted on its own centers in the lathe, and the working tools are given a reciprocating motion, vertically and horizontally, so as to coincide with, or follow, the motion of the work being turned. The motion of the tool is positive, and interdependent of the motion of the crank or shaft. In the lower part of the engraving, the device is



CRANK TURNING DEVICE OF NOVEL DESIGN

shown in two positions, first when operating on one and then when operating on the other crank pin of a crank shaft having two pins. While not shown in the engraving, the two disks to which the tool holder arm is connected must be positively geared together, as otherwise difficulties are sure to be encountered. To what extent a device of this kind will prove practical for the purpose for which it is intended it is difficult to say.—*Machinery.*

TABLE OF CONTENTS

INDEX OF INVENTIONS

For which Letters Patent of the United States were Issued for the Week Ending March 21, 1911,

AND EACH BEARING THAT DATE

[See note at end of list about copies of these patents.]

Bobbins, machine for automatic insertion and threading of, J. Luber........ 987,472
Boiler check, Reiter & Dout........ 987,491
Boiler flue cleaner, Eichelberger & Hibner. 987,459
Bolt anchor, D. H. Haywood........ 987,229
Bolts, rivets, etc., manufacture of, O. Briede........ 987,282
Book, blank, J. W. Gearhart........ 987,619
Boot and shoe upper, J. Buckley........ 987,214
Bottle, A. T. MacCallan........ 987,474
Bottle filling attachment for bib faucets, E. W. Carter........ 987,550
Bottle, non-refillable, C. Hecker........ 987,298
Bottle opener and closer, J. D. Thompson. 987,268
Bottles and the like, machine for attaching closures to, A. Calleson........ 987,670
Box machine, G. E. Priest........ 987,320
Box or crate, C. A. McGown........ 987,230
Brake, J. E. Wright........ 987,337
Brake lever, J. H. McClaren........ 987,310
Brick press, H. J. Flood........ 987,124
Bridle, J. Wilson........ 987,430
Broom holder, T. Salikx........ 987,503
Brush, shaving, J. P. Wright........ 987,277
Bucket, crane, J. A. Roberts........ 987,492
Buckle connection, J. W. Savage........ 987,326
Buckle, sliding tongue, H. Kerngood........ 987,570
Buckle, suspender, A. M. Ziegler........ 987,278
Burglar alarm plates, G. Dserma........ 987,220
Buttonhole, collar, C. E. Sackett........ 987,324
Camera, photographic, C. E. Hutchings........ 987,366
Can top perforating die, J. H. Kuechenmeister........ 987,144
Car brake, C. A. Barr........ 987,534
Car, convertible, M. Wise........ 987,527
Car derailing device, Reinoehl & Henderson........ 987,401
Car door locking device, J. Eagan........ 987,221
Car door operating mechanism, dumping, A. E. Elvin........ 987,222, 987,223
Car draft gear, railway, A. F. Peterson.. 987,106
Car heater, sleeping, E. H. Gold........ 987,570
Car heating system, compartment, E. H. Gold........ 987,567
Car heating system, sleeping, E. H. Gold. 987,565
Car, passenger, Skov & Scullin........ 987,329
Car replacer, J. A. Moynihan........ 987,641
Car safety coupling, freight, O. Davis.... 987,118
Car steam heating system, sleeping, E. H. Gold........ 987,566
Car switch mechanism, trolley, W. M. Snyder........ 987,503
Car wheel lathe, G. E. Greenleaf........ 987,227
Cars, end stiffener for railway, W. S. Atwood........ 987,270
Cars, speed indicator for motor, J. Onken. 987,644
Carbonic oxid, manufacture of, O. Loiseau. 987,147
Card punching machine, jacquard, M. Schoenfeld........ 987,259
Carline, H. W. Wolff........ 987,421
Carriage door lock, J. F. Streberger........ 987,651
Carriages, rocking attachment for baby, J. W. Ivers........ 987,234
Cart, self-loading, N. L. Goodwin........ 987,621
Cash register, C. A. Lundgren........ 987,149
Cash register and indicator, C. D. Grimes. 987,131
Cash register, refunding, E. J. Von Pein. 987,196
Cement brick machine, C. A. Booher........ 987,541
Chains, machine for automatically manufacturing welded wire, C. L. Graves.. 987,295
Chairs, reclining mechanism for barbers', E. B. Koken........ 987,580
Chandelier crown, W. Lumley........ 987,409
Cigar making machine, P. Haarer........ 987,457
Cigarette and cigarette tube with mouthpiece, Gueniffet & Nicault........ 987,329
Clock holder, H. Schmidt........ 987,176
Clothes pin, J. Erwin........ 987,288
Clutch shifting mechanism, F. B. Allen.. 987,665
Coal washing jigger, T. H. O'Brien........ 987,642
Coffee or tea pot strainer, A. E. Walton.. 987,516
Coin receptacle, Jamison & Michaelis........ 987,369
Collapsible box, J. H. Wilson........ 987,200
Collar and hames, universally adjustable combined horse, J. G. Friberg........ 987,127
Collar supporter, M. C. Messler........ 987,638
Color estimation, apparatus for, J. W. Lovibond........ 987,148
Combination knife, W. F. Carkin........ 987,548
Combination lock, Smith & Spencer........ 987,265
Combustion, promoting, J. H. Parsons........ 987,316
Composition of matter for use in making roads and making said composition, E. A. Paterson........ 987,597
Computing machine, H. Marshall........ 987,150
Concrete and steel tie, A. Westing........ 987,520
Concrete block mold, A. E. Potter........ 987,319
Concrete construction for posts and columns, reinforced, Rubello & Santi.... 987,172
Concrete post mold, H. B. & L. A. Shultz. 987,499
Conveyer, V. Johnson........ 987,302
Conveyer support, H. W. Sanner........ 987,325
Cooking utensil, A. T. MacKenzie........ 987,386
Cooking utensil, J. Thorne........ 987,510
Cooler, C. L. Hendrix........ 987,461
Coop, collapsible, F. D. Bergman........ 987,281
Cotter pin tool, D. O. C. Kersten........ 987,238
Cotton chopper, J. J. Crow........ 987,435
Counter, S. W. Wardwell........ 987,273
Crank hanger, adjustable, C. L. Jenness.... 987,370
Cream tester, M. C. Campau........ 987,613
Crutch, adjustable, Shadell & Cassidy........ 987,497
Cultivator and plows, fertilizer drill attachment to, W. F. Marsh........ 987,388
Current controlling apparatus, W. N. Dickinson, Jr........ 987,441
Cutter head, expansion, H. J. Mitchell........ 987,479
Decorticating machine, J. Brolin........ 987,342
Dental prosthesis, preparing and coloring plastic substances used as bases in, L. Ellertsen........ 987,451
Derrick for stacking hay, etc., C. O. Kinney........ 987,305
Die. See Can top perforating die.
Dish washing machine, G. Brander........ 987,544
Dish washing machine, W. C. Schrader.... 987,602
Display rack, O. L. Smith........ 987,183
Ditching and grading machine, J. D. Martin........ 987,470
Ditching machine, H. Matthies........ 987,249
Door check, H. K. Fairall........ 987,289
Door check, J. H. Young........ 987,529
Door, cold storage room, E. J. Wirfs........ 987,526
Doors, sliding, J. Fleischer........ 987,123
Dough divider and sealer, C. A. Hultin.... 987,231
Draft gear, T. L. McKeen........ 987,312
Draft gear, J. F. Courson........ 987,432
Driving gear, W. Bell........ 987,539
Driving mechanism, intermittent, A. E. H. J. Thoeldjen........ 987,509
Dropper and standard, H. A. Westmoreland........ 987,199
Dyeing machines, revolving collapsible beam for, F. M. Morton........ 987,480, 987,481
Dyes for wool, monoazo, W. Herzberg........ 987,362
Dyestuff, direct dyeing cotton, Turner & Dean........ 987,417
Edge trimming machine, A. S. Vose........ 987,656
Electric heater and sterilizer, J. G. Wallmann........ 987,658
Electric induction furnace, W. Rodenhauser........ 987,404
Electric light switch for telephone booths, S. M. O. Grant........ 987,357
Electric meter recorders, actuating means for, C. M. Page........ 987,254
Electric switch, O. B. Whipple........ 987,200
Electrical distribution system, W. A. Turbayne........ 987,194, 987,270
Electrical distribution system, A. S. Hubbard........ 987,300, 987,301
Electrical distribution system including a metering panel board, metering, E. F. Skeel........ 987,650
Electrical generators and motors, method of and apparatus for cooling, F. G. Baum........ 987,536
Electrical regulating apparatus, W. A. Turbayne........ 987,193
Electrical switch, W. A. Turbayne........ 987,192
Electrolytic cell, V. E. Goodwin........ 987,622
Electromagnet, alternating current, D. L. Lindquist........ 987,146
Electrothermal controlling apparatus, Haymond & Potter........ 987,228
Elevator, P. Wright........ 987,663
Elevator and dumb waiter systems, push button control for, E. L. Dunn........ 987,446
Elevator operating system, E. L. Dunn.... 987,673
Engine. See Oil engine.
Engine, D. R. Scholes........ 987,177
Engine heat radiating structure, J. W. Hasburg........ 987,361
Engine starter, J. W. Biddinger........ 987,105
Engines, electric ignition system for explosion, Thompson & Moeller........ 987,188
Escapement mechanism, O. McCann........ 987,153
Excavating and transporting soil, etc., apparatus for, G. E. Field........ 987,352
Excavating machine, L. C. Wood........ 987,660
Excavator shovel, H. G. Butler........ 987,612
Expansion bolt, A. Law........ 987,381
Eyeglasses, L. F. Adt........ 987,100
Fare register, J. F. Ohmer........ 987,043
Farm gate, T. S. & S. T. Heggen........ 987,574
Faucet, push button, G. R. Long........ 987,633
Faucet, self-closing, H. G. Cordley........ 987,218
Feeder, boiler, W. Houser........ 987,140
Fence post, W. J. Mettler........ 987,251
Fence post, J. W. Meyer........ 987,639
Fence post and fence wire fastener, H. Peterson........ 987,485
Fence post mold, W. L. Keller........ 987,303
Fence tightening post, N. F. Howard........ 987,305
Fibrous or cellulose materials, treating, J. H. Ketcheson........ 987,629
File case, account book, C. W. Wynne.... 987,210
File, prescription, S. G. Eghan........ 987,122
Filing cabinet, C. M. Harris........ 987,625
Filling device, F. Wendling........ 987,518
Film pack adapter, H. M. H. Glover........ 987,620
Fire, apparatus for life-saving in case of, F. Scherrer........ 987,404
Fire protecting and signaling apparatus, A. Busch........ 987,609
Fire resisting shutter, automatic, E. H. McCloud........ 987,154
Firearm, H. B. Febiger........ 987,350
Firearm, T. Consentino........ 987,672
Firearm trigger mechanism, automatic, H. Borchardt........ 987,543
Fish, drying, E. Passburg........ 987,394
Fishing float, C. Williams........ 987,522
Fishing reel, J. vom Hofe........ 987,628, 987,676
Flour of maize, making, A. & A. Brosa.... 987,560
Flue plug, S. Adams........ 987,009
Flushing machine, street, J. I. Brorby.... 987,545
Flying machine, M. A. Parisano........ 987,596
Flying machine, O. & W. Wright........ 987,662
Folding box, S. Bachmann........ 987,280
Folding stand, R. L. Cooley........ 987,113
Folding table, K. G. Johanson........ 987,236
Food mold, S. B. Ljutica........ 987,470
Foundation apparatus, S. K. Smith........ 987,266
Funnel, collapsible, A. L. Harrington.... 987,360
Funnel, straining, W. S. Schuyler........ 987,261
Furnace draft operating apparatus, W. H. Schubert........ 987,496
Furnacing, preparing materials for, G. W. Coggeshall........ 987,554
Furniture clamp, D. S. Ackley........ 987,531
Gage. See Pressure gage.
Game counter, H. Marshall........ 987,151
Garment hanger, H. Tueckmantel........ 987,416
Garment stretcher and presser, N. M. Deal 987,615
Gas calorimeter, recording, C. H. Beasley et al........ 987,537
Gas generator, T. de Fontaine........ 987,618
Gas generator, gasolene, T. A. Davis........ 987,438
Gas igniting fixture, electric, H. Younker. 987,339
Gas meter, W. H. Knight........ 987,379
Gas meters, frost water shield for, A. J. Cockerell........ 987,111
Gas pipes, dust catcher for, T. Durnbaugh........ 987,559
Gas producer, B. Versen........ 987,195
Gas regulator, Harrison & Noad........ 987,459
Gate fastener, R. O. Lewis........ 987,409
Gearing, R. Omlanolo........ 987,484
Gearing, frictional, A. C. Long........ 987,308
Glass articles, machine for making, G. E. Cleveland........ 987,671
Glass cylinders, apparatus for blowing, H. F. Hitner........ 987,137
Glass pot stopper, C. L. Betz........ 987,212
Grapple, H. F. Kohler........ 987,242
Grinder attachment, Jensen & Le Blanc.... 987,408
Grinding and dressing machine for castings, B. Toth........ 987,511
Grinding and jointing appliance for planers, H. J. Mitchell........ 987,478
Grinding machine, cutter, H. E. Eberhardt........ 987,449
Grinding machine for sharpening edged tools, E. S. Mummert........ 987,580
Gun closure safety device, M. Hermsdorf.. 987,133
Gun, recoil, M. Hermsdorf........ 987,462
Gun trigger device, H. Votsch........ 987,514
Hammer, granite surfacing, T. O. Snyder. 987,502
Harness releasing apparatus, Binnie & McCarthy........ 987,213
Harrow, H. M. Rhodes........ 987,680
Harrow weeder, P. B. Bateman........ 987,535
Harvesting machine, corn, F. King........ 987,378
Hat fastener, N. H. Hassel........ 987,297
Hat pin, E. E. Westfall........ 987,519
Hat pin protector and fastener, J. W. Barnard........ 987,533
Hat sweat band, B. Z. Smith........ 987,501
Hatch cover, self-operated, G. & S. Walker 987,197
Hay rack, I. Kern........ 987,377
Heater, G. F. Lidy........ 987,382
Heating system, E. H. Gold........ 987,568
Heating system, multiple regulation, E. H. Gold........ 987,569
Hinge, adjustable, C. K. Wolf........ 987,207
Hinge, double-acting spring, O. Katzenberger........ 987,467
Hoist, freight, R. W. Wetherill........ 987,418
Hoisting apparatus, F. Fischer, Jr........ 987,453
Hoisting device, Dillon & Little........ 987,348
Hopper, H. W. Welsh........ 987,517
Horse stopping device, runaway, J. Rinaldi 987,600
Hose coupling, O. A. Hodinger........ 987,463
Hose patch and applying tool, B. Hoover.. 987,230
Hydrant, J. F. Ferry........ 987,290
Hydrant, A. Ceranek........ 987,614
Hydromobile, M. W. Tebyrica........ 987,508
Hydrosulfites, dehydrating hydrated, H. Rey........ 987,170
Ice creeper, B. Burgess........ 987,109
Incandescent mantles, manufacture of, T. Terrell........ 987,333
Incubator heater regulator, C. E. Adair.. 987,664
Indicating device, F. R. Paine........ 987,255
Indicating mechanism, C. B. Stilwell........ 987,186
Inhaler, J. Wilkie........ 987,204
Integrator, automatic, F. E. Pendleton.... 987,165
Internal-combustion apparatus, constant pressure, E. P. Noyes........ 987,160
Iron manufacture, R. B. Carnahan, Jr.... 987,549
Iron plates of large area, manufacture of thin electrolytic, W. Pfanhauser........ 987,318
Ironing and pressing machine, P. Jonesku, reissue........ 13,220
Ironing board, C. W. Springford........ 987,267
Ironing board, H. M. Eagon........ 987,448
Ironing machine, H. R. Rose........ 987,323
Jigger, W. Seltner........ 987,179
Joint. See Air-tight joint.
Kinetoscopes, film feeding mechanism for, W. J. Symons et al........ 987,506
Labels or bands on filled bottles, machine for pasting, F. E. Jagenberg........ 987,235
Lacing fastener, W. E. Cram........ 987,556
Ladder, extensible, W. Mayer........ 987,585
Ladder, safety car, M. F. Saling........ 987,258
Lamp bracket, automobile, R. H. Rohrer.. 987,322
Lamp changer, electric, M. Ferguson........ 987,562
Lamp, pocket, J. C. C. Lens........ 987,247
Lamp socket, N. Marshall........ 987,152
Lamp socket cap, electric, G. W. Goodridge........ 987,356
Lamp socket, electric, G. B. Thomas........ 987,414
Lamp, tungsten incandescent, J. J. O'Brien 987,483
Lamps and other articles, bracket for supporting, G. W. Houk........ 987,139
Latch attachment, door, A. W. Upton........ 987,271
Latch lock, D. W. Tower........ 987,190
Lathe, metal spinning, F. A. Schulz........ 987,405
Lathe tool, A. H. Ihsen........ 987,233
Lawn trimmer, A. L. Champion........ 987,552
Lecithin, lecith-albumin, and their byproducts out of raw material containing lecithin, obtaining, Habermann & Ehrenfeld........ 987,133
Lens grinding machine, S. W. & R. G. Robinson........ 987,403
Level, J. B. Smith........ 987,182
Life rail, cap course, and gutter construction, J. F. Booraem........ 987,542
Life saving device, Gawenda & Marko........ 987,354
Line drying reel, E. Spencer........ 987,411
Linotype machine, S. M. Lummus........ 987,473
Liquid dispensing apparatus, W. E. Hodgdon........ 987,363
Liquid feeding device, C. Martini........ 987,248
Liquid self-igniting device, S. B. Battey.. 987,104
Liquid suspended in another liquid, apparatus for separating and collecting particles of one, Cottrell & Speed........ 987,116
Liquid suspended in another liquid, separating and collecting particles of one, F. G. Cottrell........ 987,114
Liquid suspended in another liquid, separating and collecting particles of one, Cottrell & Speed........ 987,115
Liquid suspended in another liquid, separating and collecting particles of one, Cottrell & Wright........ 987,117
Lock. See Carriage door lock.
Lock, Duryea & Kern........ 987,287
Lock and latch, A. J. Thornley........ 987,655
Locking key, F. R. McBerty........ 987,637
Locomotive ash pan cleaning device, N. Olson........ 987,591
Loom protector mechanism, A. J. Chevrette........ 987,110
Loom shuttle, W. H. Wilson........ 987,524
Looms, spring shuttle beater for power, O. Hallenslesen........ 987,623
Lumber stacker, edge piling, G. F. Steedman........ 987,185
Machine tool chuck attachment, F. O. Wells........ 987,659
Manure loader, J. C. Walter........ 987,198
Matrix press, electrically heated, H. B. Gale........ 987,293
Measure, steel tape, K. G. Shutt........ 987,500
Measuring device, temple, E. L. Nero.... 987,313
Measuring vessel, Bender & Downey........ 987,211
Meats during curing, overhauling, W. C. Cypes........ 987,488
Mechanical movement, P. Lord........ 987,383
Metal founder's mold, J. F. Digan........ 987,442
Metal planer, W. T. Sears........ 987,263
Metal prop, flexible, A. Pittroff........ 987,397
Metal, ribbed expanded, J. Kahn........ 987,374
Microscopes, fine adjustment for, Ott & Leuchsenring........ 987,393
Milker's tail clamp, W. H. Ostrander.... 987,594
Mirror support, W. E. Conroy........ 987,346
Mold, W. E. Fobes........ 987,225
Mortise and tenon hopper joint machine, J. H. O'Neill........ 987,163
Mouthpiece grinding, facing, and polishing device, C. H. Lind........ 987,383
Mowing machine, A. Monroe........ 987,588
Music stand, J. Caputi........ 987,547
Music turner, sheet, C. E. Bell........ 987,538
Musical instruments, pneumatic action for, O. Higel........ 987,575
Nail box, G. H. Dahlke........ 987,557
Nail feeding device, A. M. Taylor........ 987,331
Necktie retainer, W. A. Huth........ 987,367
Nippers, F. Sale........ 987,173
Nitrogen compounds, producing, A. R. Frank........ 987,674
Nozzle reinforcing means, H. C. Fritz.... 987,226
Numbering machine, multiple, C. L. Johnston........ 987,372
Nut lock, E. A. Blanton, Jr........ 987,106
Oil burner, black, J. W. Elder........ 987,617
Oil can, non-explosive, J. J. Long........ 987,583
Oil engine, H. B. Leech........ 987,246
Oil engine, J. H. Bunker........ 987,283
Operating table for use of physicians and surgeons, B. D. Thorner........ 987,189
Ore concentrator, H. E. Wood........ 987,209
Ores and for the electrolytic deposition of gold and silver and other metals from solutions containing said metals, apparatus for the treatment of, F. C. Brown........ 987,428
Ores, treatment of sulfid, J. A. McLarty.. 987,156
Oven, electric, G. J. Ogden........ 987,161
Ovens, kilns, or other structures, door for, E. H. McCloud........ 987,155
Oxygen, making nitrogen, K. Kaiser........ 987,375
Pad making machine, W. Dichmann........ 987,440
Paint, M. J. Waugh........ 987,605 to 987,608
Pan. See Bake pan.
Paper feeding mechanism for machines for manufacturing envelops, etc., Spannuth & Dunnebier........ 987,682
Papers, producing, W. H. Howes........ 987,678
Paring apparatus, W. H. Boutell........ 987,108
Pencil, cerographic, Reimann & Schneider. 987,169
Perforator, S. H. Wiberg........ 987,201
Photographic apparatus, bellows support for, C. E. Hutchings........ 987,232
Picture films, coating, W. A. Daniels.... 987,437
Pipe coupling, J. H. Allan........ 987,683
Pith boring device, C. Nave........ 987,314
Planer head, matching, H. J. Mitchell.... 987,301
Planter and fertilizer distributer, corn, W. B. Myers........ 987,482
Plow, F. D. Tarver........ 987,507
Plow drag attachment, J. Dengel........ 987,286
Plow, motor, W. Strohmer........ 987,652
Plow, reversible disk, A. P. McKay........ 987,477
Plow standard and brace, pivoted, Pledger & Campbell........ 987,487
Plug, testing, J. Leisinger........ 987,145
Plumb for corners, pilasters, etc., C. O. Bethel........ 987,424
Plumber's stand for vises, foldable, A. Smith........ 987,180
Plungers, antifriction device for lower ends of, E. Atwood........ 987,666
Pocket garment, D. Ginsburg........ 987,584
Potato digging machine, A. Wichertjes.... 987,202
Poultry fountain, W. W. Chambers........ 987,551
Poultry, vermin exterminator for, W. F. Crawford........ 987,433
Power generator, W. J. Neilson........ 987,158
Power transmitting device, G. E. Molyneux........ 987,640
Presses, housing for roller straightening, C. D. Dishong........ 987,443
Pressure and damper regulator, J. B. Bischoff........ 987,610
Pressure gage, J. Dewrance........ 987,219
Primary battery, C. B. Schoenmehl........ 987,647
Printing, E. L. Fell........ 987,351
Pulley, belt conveyer, E. H. Messiter.... 987,157
Pulp strainer, R. Wagner........ 987,657
Pump, Connor & Miller........ 987,217
Pump, T. Meissner........ 987,313
Pump, air lift displacement, F. S. Miller.. 987,679
Pump bracket, automobile, F. E. Ten Eyck 987,332
Pumps and drills, means for operating walking beams of deep well, G. M. Bradrick........ 987,427
Pumps, lining plunger for oil well, Daniels & Burgess........ 987,347
Punch, W. J. Godwin........ 987,355
Rack. See Display rack.
Rail anticreeping device, E. M. Smith.... 987,181
Rail bond, A. B. Herrick........ 987,136
Rail chair, J. F. Kersteter........ 987,578
Rail clamp, guard, Reinoehl & Henderson. 987,400
Rail, guard, F. B. Bradley........ 987,611
Rail, guard, T. Carmichael, reissue........ 13,218
Rail joint, A. C. Jorns........ 987,373
Railway chair and plate, M. Shelton........ 987,498
Railway rail, rolled manganese steel, W. S. Potter........ 987,167
Railway rail tie, metallic, W. W. Andrew 987,101
Railway signal, J. W. Johnson........ 987,371
Railway signal, J. H. Struble........ 987,653
Railway switch slide plate, Reinoehl & Weaver........ 987,402
Railway tie, Mowry & Anderson........ 987,252
Railway track, J. J. Ingersoll, Jr........ 987,464
Rammer, chain, D. Vogeler........ 987,513
Ratchet head and lever therefor, Grimm & Dhooge........ 987,132
Razor, C. P. Clark........ 987,553
Razor, safety, C. F. Ern, Jr........ 987,453
Registering system and apparatus, N. H. Holland........ 987,384
Resilient wheel, W. Besler........ 987,340
Rocks containing potassium, treating, A. S. Cushman........ 987,436
Rope drive elevator, Lindquist & Sundh... 987,384
Rotary engine, compound, I. K. Siverison. 987,264
Rotary explosive engine, J. C. & R. T. Peterson........ 987,486
Rules, device for holding plumb, J. O. Swenson........ 987,187
Sage brush cutting and lateral ditching machine, combined, Mahoney & Durant 987,387
Sash fastener, F. Shore et al........ 987,409
Sash lock, W. K. Dare........ 987,282
Sash lock, W. H. Dow........ 987,558
Sash lock and opener, combined, C. D. Tabor........ 987,330
Sash weights, apparatus for molding seamless, A. S. Hodges........ 987,290
Scaffold, S. Rashkovsky........ 987,390
Scale attachment, wagon weighing, W. D. McClelland........ 987,587
Scale, platform, E. C. Sewy........ 987,181
Scale, platform, J. Himmes........ 987,627
Screen. See Window screen.
Screw bolt, W. F. Kenney........ 987,142
Sectional wheel, E. B. Fitzgerald........ 987,224
Serving device, T. J. Burke........ 987,420
Sewer construction, J. L. Potter........ 987,398
Sewing machine attachment, S. Riner........ 987,601
Shaper guard, P. Erickson........ 987,452
Sheet fastener, G. L. Edgerton........ 987,349
Shell or projectile, W. L. Murphy........ 987,590
Shuttle blocks, manufacturing, W. Mitchell 987,392
Sign, illuminated, H. E. Westerberg........ 987,274
Sign, illuminated, L. A. Watkins........ 987,335
Size, manufacturing, L. Paechtner........ 987,595
Skirt marker, R. Sideman........ 987,327
Sled brake and guide, S. Severson........ 987,681
Sleigh, motor, Guttormson & Hast........ 987,573
Slug or type casting machines, feeding attachment for, J. G. Rauch........ 987,489
Small arm, P. Mauser........ 987,584
Snap switch, C. J. Klein, 987,239 to 987,241, 987,306, 987,632
Snap switch, S. Korf........ 987,581
Snow, road machine for melting, C. M. Brooker........ 987,343
Soda water straws, machine for holding and dispensing, R. J. Woodbury........ 987,276
Soldering device, F. S. Chapman, reissue.. 13,219
Sound box, J. A. Williams........ 987,205
Sounding apparatus, F. Schubert........ 987,260
Speed changing mechanism, W. C. Conant. 987,430
Spindle, H. L. Brown........ 987,546
Spinning machine, D. O. Pease........ 987,317
Spring frame, adjustable reclining, A. R. Barnett........ 987,423
Spring trip foot adjusting device, C. E. Thomas........ 987,604
Spring wheel, Tremmel & Christensen........ 987,191
Sprinkler, Stow & Vickery........ 987,413
Stalk crop handling machine, J. B. Schuman........ 987,406
Stalk cutter, D. McDowell........ 987,311
Stanchion, A. F. A. Tidyman........ 987,269
Stay bolt for steam boilers, F. J. Connors. 987,431
Steam plant system, J. C. Quinn........ 987,168
Steel, compound for treating, Lee & Booth 987,468
Stencil machine, S. D. Harbog........ 987,626
Stoker, mechanical, W. R. Wood........ 987,661
Stone and metal shaping machine, W. F. Meyers........ 987,390
Store front construction, F. Fritz........ 987,143
Stove regulator, gas, C. S. Harris........ 987,458
Stretching apparatus, C. J. & J. Gauer.... 987,456
Stuffing box, J. Hahn........ 987,296
Supporting mechanism, A. Scheible........ 987,175
Suspending structure for fragile articles, Oglesby & Ayton........ 987,162
Swing, circular pleasure, J. A. Whitlock.. 987,419
Switch. See Electric switch.
Switch, E. E. Yaxley........ 987,338
Switch throwing device, automatic, J. W. Iron........ 987,465
Switching device, H. F. Gordon........ 987,294
Talking machine motor, L. P. Valiquet.... 987,272
Tankage and manure press, J. J. C. Singleton........ 987,649
Telegraph and telephone system, O. T. Lademann........ 987,582
Telegraph key, C. Bolick........ 987,107
Telegraphy, quadruplex, I. Kitsee........ 987,630
Telegraphy, quadruplex printing, I. Kitsee. 987,631
Telephone, W. J. C. Kenyon........ 987,304
Telephone attachment, C. L. Fields........ 987,563
Telephone exchange system, W. A. Fricke. 987,128
Telephony, W. A. Fricke........ 987,129
Testing apparatus, W. S. Bickley.987,609, 987,667
Tie plate, sheet, W. F. Scott........ 987,407
Tilling the ground, machine for, H. Kerrinnes........ 987,577
Tire, W. D. Furey........ 987,292
Tire and tire carrying rim for the wheels of motor cars, J. S. Clarke........ 987,344
Tire saver, L. Willour........ 987,523
Tire, vehicle, E. C. Bruen........ 987,668
Tires, metal rim for vehicle, J. C. Cole.. 987,216
Toilet, M. E. Connelly........ 987,112
Tool, combination, B. C. Dillon........ 987,120
Tool holder, A. Lawson........ 987,307
Tooth, artificial, H. Wiemann........ 987,203
Transportation system, cable, F. Neale.... 987,253
Trap, W. J. Clark........ 987,284
Trap, L. C. Accola........ 987,530
Trolley wires, insulating hanger for, J. L. Wagner........ 987,515
Trousers, A. W. Stern........ 987,412
Truck, tray, O. Olson........ 987,592
Trunk roping and fastening appliance, J. M. Robinson........ 987,321
Trunk, wardrobe, G. H. Wheary........ 987,275
Tube rolling machine, O. Pfrengle........ 987,598
Tuning instrument, L. W. Neeross........ 987,159
Turbine, elastic fluid, B. Wolff........ 987,336
Turnstile, C. Driver........ 987,445
Typewriter, J. W. Barnberger........ 987,103
Umbrella, folding, W. C. Wolfe........ 987,208
Valve, W. J. Theis........ 987,334
Valve, E. Dwyer........ 987,447
Valve, R. C. Green........ 987,571
Valve mechanism comprising a rotary valve, W. W. Clark........ 987,215
Valve mechanism for internal combustion engines, A. E. Osborn........ 987,164
Vaults, mold for making burial, C. K. Haw........ 987,134
Vehicle box, adjustable, F. D. Sieman.... 987,328
Vehicle, motor, W. Denton........ 987,119
Vehicle, motor, E. Gruenfeldt........ 987,358
Vehicle top backstay fastener, T. W. Pickard........ 987,396
Vehicle wheel, resilient, R. T. Evans........ 987,561
Vending machine, B. Lovatt........ 987,634
Vending machine, coin controlled, J. G. C. Mantle........ 987,636
Ventilator, R. L. Creacy........ 987,434
Ventilator, E. Stephany........ 987,504
Vest holder, M. Schwartz........ 987,262
Wagon rack, dumping, W. W. Ditmer........ 987,121
Wagon running gear, J. R. McAllister.... 987,586
Washington machine operating mechanism, G. N. Myers........ 987,389
Watch retainer, safety, F. M. Franklin.... 987,291
Water and steam coupling, Reiter & Dout 987,490
Water distributing system, H. E. Martin. 987,475
Water economizer, C. De Shon........ 987,616
Water heater, electric, Roche & Ray........ 987,493
Water, vacuum, and pressure gage, automatic regulator, and safety device, combined, W. T. Fowden........ 987,125
Weaner, calf, F. W. Widmann........ 987,521
Weather strip, metal, A. M. Lane........ 987,244
Weeder, Vanskike & Ebert........ 987,512
Weevil, compound for destroying boll, R. B. Armentrout........ 987,102
Wheat scouring machine, N. L. Heldman 987,460
Wheel. See Resilient wheel.
Wheel with multiple and balanced rims, H. Lotte........ 987,471
Wheels or pulleys, manufacturing, E. H. Jones........ 987,141
Whip socket, Reschke & Rumford........ 987,257
Windmill, J. O'Toole........ 987,645
Window screen, W. Thomson........ 987,654
Windows, automatic locking device for sash, C. A. Halbach........ 987,675
Wood splint cutting machine, F. Schafer. 987,174
Wood splitting machine, M. J. Power, reissue........ 13,221
Wooden article and producing same, compressed, J. W. Hyatt........ 987,368
Wrench holder, adjustable, M. M. Kerr.... 987,237
Wrench, E. C. Doolittle........ 987,444
Wringer and washing machine attachment, W. E. Flood........ 987,353

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